SEATED WORKING POSTURE

\- A Research Thesis with
Experimental Methodology
and Literature Review

SUBMITTED BY:-

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ABSTRACT

Much has been written about seated working posture - particularly in the late 19th and early 20th centuries, and the furniture associated with achieving what is commonly referred to as the "German Square" postural geometry (after Mandal, 1974). The physical sciences aspects of chair, desk and associated furniture ancillary to the task required of the seated worker, have been described in the scientific literature and the standards and guideline publications of the authorities of many countries of the western world. The most important contribution of multi-adjustable furniture to the reduction of postural discomfort and musculo-skeletal complaints is recognised. As a result a variety of standards and guidelines concerning some of these aspects exists in countries such as the United Kingdom, Canada, United States of America, Germany, Australia and the Scandinavian countries. The International Organisation for Standardisation published document TC136/SC7 in 1978, consolidating such existing standards.

Less emphasis has been placed on the interface of the information exchange and the comfort, performance and preferences of the seated worker; ie., the practically, the comfort and the intrinsic safety of the working posture prescribed by the model established by the many standards. Existing specifications and guidelines differ in their orientation towards operator performance and comfort of the operator, in as much as some purport to be "furniture standards", for example C.E.N, Comite European de Normalisation, Paris, 1980, while others purport to be "postural standards", for example, International Organisation for Standardisation document TC 136/SC7 (1978). The standards are uniform in matters of upright trunk and 90^{o} upper and lower limb geometry, but are divided in the lineal dimensions applied to eye height above the floor, shoulder acromion to home row of keys (or pen-grip position of the dominant hand and fingers), and eye distance to copy.

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The relationship between comfort and performance of seated workers is not well understood and is likely to be complex. Comfort and performance are not necessarily positively correlated. The effect upon operator comfort and performance of the "German Square" postural model and the furniture advertised as "ergonomic" and multi-adjustable, currently available has been cited by Mandal, 1974 and 1985. Corlett (1981) warned that "we cannot afford to ignore posture, ...", whereas Leibowitz (1967) when discussing the many variations in chair design remarked about seated posture that "we have accustomed ourselves to habitual modes of use that are literally disfiguring".

This paper examines the literature available on the related topics of furniture design and seated posture. The paper relates this information to the "postural" and "furniture" standards of authorities, particularly the International Organisation for Standardisation document TC 136/SC7 published in 1978. The conclusion is that such standards are not based on adequate scientific investigation.

A methodology based on that used by Grandjean et al (1983) has been adapted to measure the seated postural preferences of ninety-four data-processor operators within Australia Post. All operators within the two separate experimental groups examined, had received uniform training in the "German Square" seated posture technique prior to commencement of work as a data processing operator within Australia Post. Six separate geometric body angles were observed and three separate linear dimensions were measured for each subject at two and eight minutes durations after the operator commenced work. The findings of the experimental measuring show that none of the operators adopted the "German Square" sitting posture and none of the operators worked in a basically still posture over the observation time.

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The results indicate a reclined trunk seated working posture with substantial degrees of freedom to move over periods of concentrated working time, is preferred by most operators within the experimental groups. All results show very different seated working postures to those depicted in the text book references and derived from that modelled by the International Organisation for Standardisation (1978).

The conclusion of the study is that the results should have a profound effect upon the training postural model known as the "German Square", currently taught internationally to seated workers, but the results also demonstrate that many postural relationships of comfort and performance of seated workers require further research.

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1. INTRODUCTION

Compared to primitive man living an outdoor life, civilised man has become a "standing-around, and a sitting-down animal, rather than a running-around one" (Drew, 1926). Modern man is subjected to "an altered environment to which the body adapts itself automatically" (Drew, 1926). Nearly all modern man's activities encourage the forwards position of the arms and head, with a tendency of gravity to pull the body forwards and downwards (Zacharkow, 1988).

Cultures where other resting postures such as squatting or kneeling predominate, like that of the native Bushman of the Kalahari desert in Southern Africa (Weissner, 1978), also show transition to the western sitting posture upon a chair with simultaneous transition to industrialisation (Helbig, 1978). With the transition to industrialiation, there is actually " a demand for static and sedentary modes of living" (Barlow, 1946). As Bennett (1928) stated, "the most universal physical occupation of civilised human beings is sitting". In regards to school, Bennett (1928) stated that "civilisation has imposed upon the child one of the most distinctly sedentary occupations ever devised". It is in the artifical environment of the school where the child's postural habits will be formed for life (after Zacharkow, 1988).

Corlett (1981) warned that "we cannot afford to ignore posture, primarily because to do so creates such wide spread misery and secondarily because the costs, both the social costs of unnecessary disease and direct cost in loss productivity, are more than any modern industrial nation should be prepared to pay".

In regards to the chair, Aveling (1879) commented that "of all the machines which civilisation has invented for the torture of mankind, - there are few which perform there work more pertinaciously, widely, or cruelly, than the chair. It is difficult to account for the almost universal adoption, at least in this country, (U.S.A), of such an unscientific article or furniture". Coghill (1941), referred to the chair as "the most atrocious institution hygienically of civilised life".

Leibowitz (1967) remarked that " --- hundreds of variations upon the shape of the chair have been produced, many differing enormously in terms of how one must sit in them. Indeed, we, of the chair, have made the compromise. We have agreed to adjust our bodies to the dictates of the chairs; only rarely do we find a chair in its design has contracted to fulfil the requirements of the human body. In such ways we have permitted the forms and products of our culture to change our body alignments in order to satisfy these structural requirements. We have accustomed ourselves to habitual modes of use that are literally disfiguring".

Posture and seating authorities from over 100 years ago stressed the extreme importance of appropriate postural habits and appropriate seating for both school children and adults (Bennett, 1928; Aveling, 1879; Mosher, 1899; Cohn, 1886; Lewis, 1899; Kotelmann, 1899; Shaw, 1902; Dresslar, 1917). The works of the scientists cited of the late 19th century and early 20th century are important and relevant today.

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In view of the almost forgotten literature about this subject from the late 19th and early 20th centuries, authorities throughout the western world have created models of correct sitting position that are based on right-angled upper and lower limb geometry and upright trunk sitting position. The International Organisation for Standardisation (1978) modelled this as an ideal sitting position. The same type of standard forms the basis for international standardisation of furniture, for examples the Commite European de Normalisation, Paris, France (1978), and the International Organisation for Standardisation (1978), Kohln, G.D.R, (1978), and is also used for the training internationally of furniture designers, for examples, the models set up by the authorities of the United States of America (Mil-Stnd-1472C, 2 May, 1981), and Denmark by the Danske Arkitekters (Danish Architects), Landsforbund, Skolemmobler, Copenhagen, 1981.

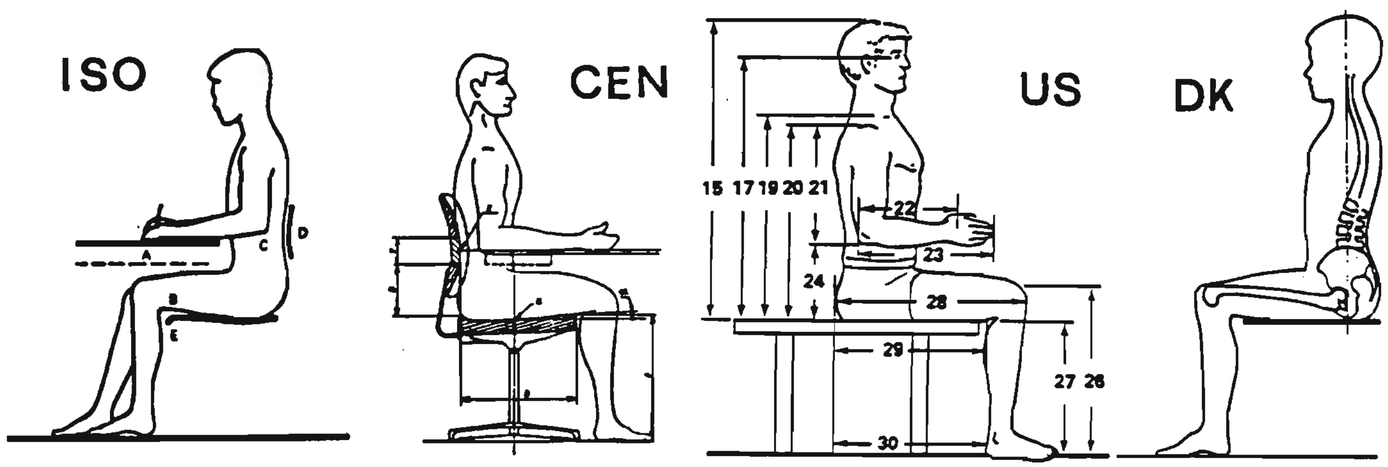

FIGURE 1. The Postural Models Established by the International Organisation for Standardisation (1978); the Commite European de Normalisation (1978); the North American Government (1981); the Danish Architects (1981).

The models such authorities have published have people sitting with the joints at the ankles, knees, hips and elbows all making right angles, with the legs together and parallel and the upper arms tucked into the body sides with the forearms and hands parallel. This architectural-like presentation shows subjects in side elevation sitting with a concave curve in the small of the back and staring into space.

Authorities such as I.O.S. (1978), do not explain the origin of the concept(s) of the drawings and there is no published connection with scientific observation. Bibliographics published with such standards do not shed any light upon the origin(s) of the upright trunk and right angle upper and lower limb geometry installed as the "ideal" sitting posture. Nor do they make reference to physiological or anatomical data to support the notion of sitting still to perform the work.

Mandal (1985) presumed that the modelled seated working position, for example I.O.S. (1978), takes its inspiration from the pharaoh's working position - "even the hands (of the model) adopt a position resembling the divine prototype".

FIGURE 2. The Colossi of Memnon, Remains of the Royal Mortuary Temple of Amenhotep III. (reproduced with kind permission of the Encyclopaedia Britannica).

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The deleterious effects on the spine of improper school furniture which force a kyphotic trunk posture, have been realised for a long time. As early as 1737, the school regulations of the German Princedom of Braunschweig-Luneburg pronounced the bending of the spine in sitting "unwholsome and injurious" (Kotelmann, 1899; Bennett, 1928). In Bismarck's Germany the emphasis on "Ordnung", discipline and the right angle limb geometry and upright sitting posture led to specific designs in 1884 and 1889 respectively, by F. Staffel of school furniture to place school children in this salutatory and well-ordered disciplined appearance. From this work the phrase "German Square" posture evolved.

As cited by Mandal (1985) this posture is "just like the military standing to attention, a parade position, quite in appropriate for the commencement of any real work. In fact it requires such an enormous exertion of the muscles to maintain the upright position that on the whole is impossible to do anything else."

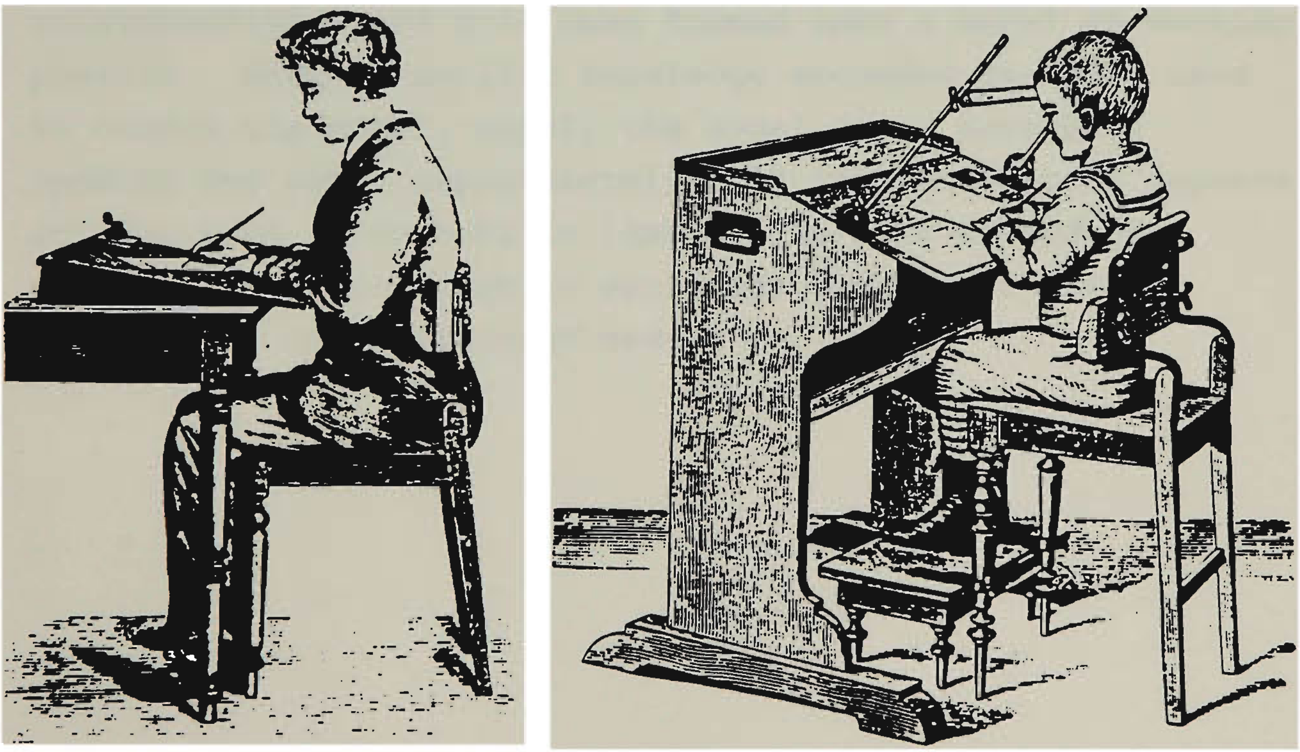

FIGURE 3. The School Desks Constructed by F. Staffel,1888. Reproduced with permission of the publisher J.F. Bergmann Verlag.

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In the mid and late reign of Queen Victoria in England during the latter half of the nineteenth century, office work was one of the few respectable occupations for the daughters of the middle class outside of the home environment. It was important to look respectable even at work, and corsets and crinolins forced women at work to sit upright on the edge of their chairs. Women had to sit upright even in easy chairs. Men, on the other hand, could sit as they liked in comforably upholstered chairs preferably in the privacy of their clubs since it was considered ill-mannered to lounge around when ladies where present. Nor were children spared - "children are expected to sit upright and preferably in silence" (Gloag, 1964; Mandal, 1985).

Clearly the literature of the late 19th century and early 20th century about seated working posture and related matters could have been reduced from its large number of observations to a few simple relationships. This set of relationships could have been formed into a model of working posture. When scientific knowledge exceeded the data used to create the model, simply the model could have been updated but after approximately 1930 the information appears to have been in scientific limbo. The work of modern authorities in the western world has not led to the development of a different model.

Hence, there is no such thing as the "perfect model". The best that can be achieved is the creation of a model that explains the data available at a particular point in time. Some models survive for a long time whereas other do not. The model is a tool to be used to express hypotheses and rigously evaluate their consequences. This is not to say that models are absolutely necessary. Gallileo did not require a model in order to realise that the earth was rotating. Nevertheless, as humanity becomes more refined, the limitations and costs associated with a purely experimental approach become more pronounced. This is the reason for modelling biological systems.

With experimental methods not always providing data sufficient to solve the many problems in medicine and biology, the theorist can join forces with the experimentalist. The added dimension of the theoretical modelling approach can both lead to a further understanding of the given problem and also potentially provide solutions not otherwise attainable (after Zachakow, 1988).

This study examines the scientific literature associated with seated working posture and finds no scientific link between the promotion of sitting basically still in the right angle limb geometry and upright trunk sitting position, promoted by authorities in the western world as the ideal or "correct" sitting posture.

The study presents a methodology for measuring the effects of training to sit basically still in the right angle limb geometry and upright trunk sitting posture, of a group of data processors within Australia Post. The methodology demonstrates by measured results the differences in trained and preferred sitting working postures that data processors utilise for seated visual and keyboard operation work.

The study concludes with an evaluation of the findings of the experimental measuring and a comparison between the seated postural requisites of the "German Square" model and the postures preferred for seated work by data processors.

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1. INTRODUCTION

1.1 LITERATURE REVIEW

1.1.1 Posture and Chair Design

1.1.1.1 Ancestory of the Chair

For five centuries the character of chair design has been directly connected with or influenced by architecture and social disciplines. The ancestory of the chair is mixed, and though far-distant pre-Christian origins have affected the character of the chairs, human costume and manners have often determined the shape of seats and also the posture of those seated. (Petrie, 1922).

The vast spread of the farthingale, worn by women of fashion in the late 16th and 17th centuries, was accompanied by the broad back-stool - the so called - farthingale chair, and the Victorian crinoline inspired the production of the lady's easy chair, low-seated, with an upright shell back and vestigial arms; while for centuries the hardness of flat uncushioned seats was minimised by the voluminous clothes to those who used them - even a monks habit could be bunched up to soften the surface of a stall or the cutting edge of a misericord (a folding form of lean-to seat/body support). (after Gloag, 1984).

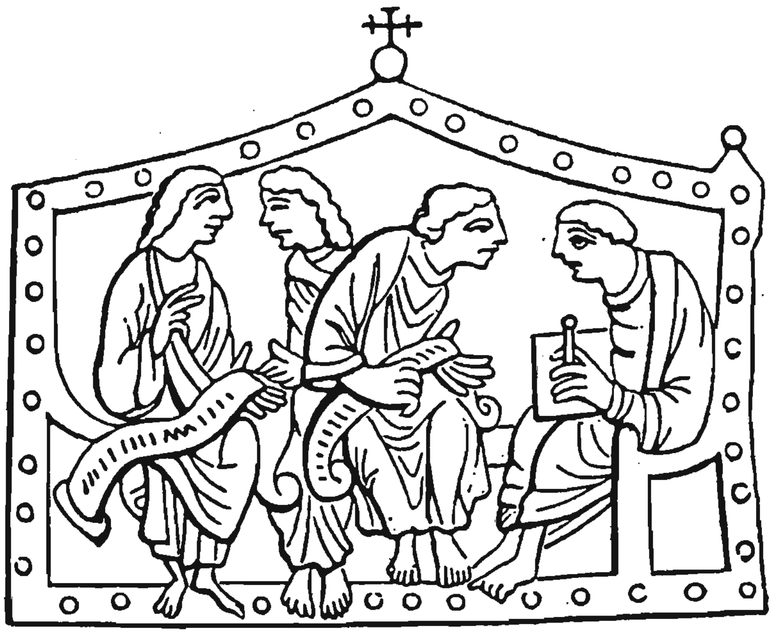

FIGURE 4. A High-Backed Settle, with Arms at Each End, and the Back Rising to a Point. From the Twelth-Century Psalter at Trinity College, Cambridge. Reproduced from "A History of Domestic Manners and Sentiments in England"; Thomas Wright, 1862.

As cited by Mandal (1974), chairs probably have always been a symbol of dignity. The African "Ashanti-stools" are thought to be the direct successors of the original chief's thrones. The Ashanti were a warrior tribe, and the British succeeded in capturing and killing several Kings, but this made little impression on the Ashanti's, who merely proclaimed a new King. The real authority lay not in the person but in the stool. Only when the British realised this in 1900 and captured the stool, they were able to subjugate the Ashanti.

Seats of most kinds, reveal the posture and carriage of the humans for whom they were made, and chairs show faithfully the importance accorded to dignity, elegance, or comfort, thus supplementing the comprehensive disclosures made by architecture about life in any period. John Gloag (1964), commented "that the architectural design of chairs indicates whether social life was afformal and rigid gracefully relaxed, casually and careless, austere, voluptuous, romantic, imitative, democractically standardized affluent, vulgar, in different to art, dull, snobbish, or poor."

1.1.1.2 Design and social character of chairs and seated posture

The history of a chair recognisable as "English" begins with the late mediaeval period, when an individual native style in architecture and the crafts became recognisable (Edwards, 1954). Although there is evidence that the chair occasionally developed in isolation (Edwards, 1954), it was often related to architecture. Thus ancient Greek chairs may have derived their initial form from the tiers of shaped marble seats in an open-air theatre just as some fifteenth-century chairs derived theirs from choir stalls (Shapland, 1927). This evolutionary process was reversed in the second half of the 17th century, when chairs were extended laterally to form double or triple seats - the so-called love-seat and the settee - with the chair back, and altered in shape or decoration, used in duplicate or triplicate (Harris, 1937).

According to Gloag (1964), chair-making began when somebody, several thousand years ago, suggested that a piece of wood layed on top of three or four stones at approximately equal height would provide a movable seat. Collecting a few stones of about the same size was a simple job compared with shifting a solid block of wood or stone from place to place, when a tribe was on the move.

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Resting a trimmed and smoothed board on stones was the first stage in the evolution of a free-standing, movable seat; the next, which must have taken many generations to reach, was to fit three or four legs to the under board, plugging them into holes bored or scraped out on the under-side, and producing as a result something that was stable, and saved the trouble of searching for supporting stones. According to Harris (1937), "as skill in wood carving improved, crued upright supports for the seat were carved, for primitive and civilised people alike have a deep need for and love of ornament, and as craftsmen generally go to nature for models, some of the earliest examples represent the legs of animals."

Breasted (1939), mentions stools supported on carved ivory legs, representing those of a bull, in the First and Second Dynastys of ancient Egypt 3400-2980BC, and for centuries the Egyptian civilisation developed the art of furnishing evolving a stylised fauna and flora for thrones, chairs and stools, and perfecting such structural inventions as the folding stool and the braced frame (Nattali, 1846). Wood has been shaped by cutting tools on a rotating surface since very early times, and there is no record of when or where the first lathe was invented. It was used by the Egyptians, Assyrians, Greeks and Romans, in the Byzantine empire and throughout the Romanesque period. Structural inventions, like joinery, led to the making of chairs with high inclined backs and the yielding seat of woven string, resembling cane-work, and this gave far more comfort than the low-backed chair born of a lesser technology. According to Richter (1926), the Greeks invented the klismos "from no Egyptian or Assyrian prototype, but apparently evolved from the simpler type of thrones". The klismos displayed concaved legs splayed outwards, the upright crossed by a shallow concave back-rest which allowed a free, natural position for those seated. Richter (1926), concluded, "the klismos is certainly one of the most graceful creations of furniture, combining comfort with elegance. For sheer beauty of line it has few rivals".

FIGURE 5. The Klismos, Greece, 5th and 4th Centuries B.C. Reproduced from "A History of Greek, Etruscan and Roman Furniture". Dr G.M.A. Richter, 1926.

Seats depicted on Assyrian bas-reliefs have an unvarying stiffness of line, and although Assyrian craftsman may have invented the fore runner of the arm chair, the work shows no advance on Egyptian standards of design and execution (personal observation).

FIGURE 6. Throne of King Sennasherib of Assyria. 8th century B.C. Reproduced from "The Englishman's Chair", John Gloag, 1964.

The relationship between architecture and chair design, established in Greece, has never been broken off, and the Greek discovery of a natural and graceful form of chairs is characteristic of the people who perfected the Doric, Ionic, and Corinthian orders of architecture, and created the system that governed the proportions of each.

1.1.1.3 Chairs and the modern movement in architecture

As cited by Gloag (1964), English architects in the 1920s and 1930s were preoccupied with what Jeffrey Scott called the "Mechanical Fallacy", and the avant-garde gave honour to the so-called "International Style", chairs of tubular metal and fabric designed with all traces of national distinctiveness consciously erased.

According to Mandal (1974), the Stockholm exhibition in 1930 "marked the start of a new epoch for Scandanavian furniture design under the motto - 'Beauty in every day furniture'. The aim was a social one. But both functional and social ideals were quickly modified as the emphasis moved towards the creation of furniture works of art. Mandal (1974), commented further that "many of the chairs produced as functional are refined instruments of torture". Mandal (1974) cites an example by the Finnish architect Alvar Aalto - the "sanatorium chair" (1939), and comments that "if patients were not already ill, they certainly would be in that furniture".

FIGURE 7. The "Sanatorium Chair" by Alvar Aalto, Finland, 1939. Reproduced from "The Seated Man - Homo Sedens", A.C. Mandal, 1985.

The architects who designed this type of chair furniture were concerned with aesthetic and technical quality, while they mostly ignored the needs of people who were to use it.

Since the Second World War, tradition has reasserted an individuality that was too strong to be permanently submerged in the prosaic anonymity of barren functionalism (Gloag, 1964). LeCorbusier (1947) stated "a house is a machine for living in", and surplanted another - "an arm chair is a machine for sitting in and so on". LeCorbusier exercised an influence on the growth and development of the modern movement by the consistent logic of his teaching that social problems are never dissociated from architectural problems, and steeped in the belief that form must follow function. The modern movement has out grown the calculated austerity of its bleak period between the world wars; its manifestations in architecture and the industrial arts have mellowed, and materials, manufacturing techniques, and the general approaches to furniture design have changed more in the past 40 years than in the previous 400 years.

1.1.1.4 Tradition and the upright sitting posture

The design of seats partly depends on the postures adopted for dignity or comfort. Different families of the human race have characteristic ways of sitting which seems to have a cultural derivation and to not have arisen because of any anatomical differences between Asiatics, Caucasians, and Negroids.

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Asiatics sit comfortably with the lower limbs arranged horizontally; a posture that has been described as the hieratic or Buddha, and is usually depicted in paintings and sculptured figures of Buddha and adopted by Buddhist priests (Paine and Soper, 1960). This sitting position has for many centuries influenced the design of oriental furniture, and by lowering the eye level of the sitter has lowered the height of seats and tables, which, by comparison with European seats and tables, seem very close to the floor (personal observation). Particularly in the Middle Eastern countries mats, carpets or cushions placed directly on the floor are often used instead of stools and chairs.

A less serene and dignified position is squatting with the legs disposed near vertically, the knees brought together below the chin, the spine curved forwards in a kyphotic shape, and the arms extended resting on the knees or clasped about them. There are two distinct variations of the squatting posture, and in the second, the individual squats on the heels or hamstrings, with the buttocks clear of the ground - a position often shown in ancient Egyptian paintings and sculpture.

The ancient Egyptians are depicted sitting upright on chairs and stools with seats of varying height, though even a low seated-chair was higher than anything Oriental, for the sitting positions of the Egyptian upper classes were the same of those of all classes in Europe. Peasants or slaves might squat, but the Pharaoh and his court officials and his bureaucrats sat with well drilled-dignity (after Breasted, 1939).

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FIGURE 8. Painting of a Chair with an X-Shaped Underframe, from the Tomb of Nebamun, Thebes, 1400 B.C. Reproduced from "The British Museum : Egyptian Antiquities", M.A. Nattali, London, 1846.

The Greeks and the Romans reclined on low couches when they dined, and the Greeks had recognised the importance of a curved, comfortable support for the back when they sat on chairs (after Richter, 1926). A flat seat and a completely vertical back throw the head off balance and give no support to the small of the back (after Mandal, 1974), but for thousands of years claims of dignity have excluded comfort, though the Greeks proved dignity and comfort were somewhat compatible in the klismos chair design.

Asiatic peoples had combined dignity with comfort in the cross-legged habitual sitting positions; Europeans, who preferred to sit upright, were prepared to sacrifice comfort, and retained the unyielding vertical chair back until the 17th century (Rowland, 1953; Harris, 1937).

Communal native tribes prefer a seat just high enough to allow the chief to look down on his squatting tribesmen as a demand of dignity; a block of wood or stone, or as technical skill advanced, a low stool, were the predecessors of the throne (after Gloag, 1964; von Rotzler, 1969).

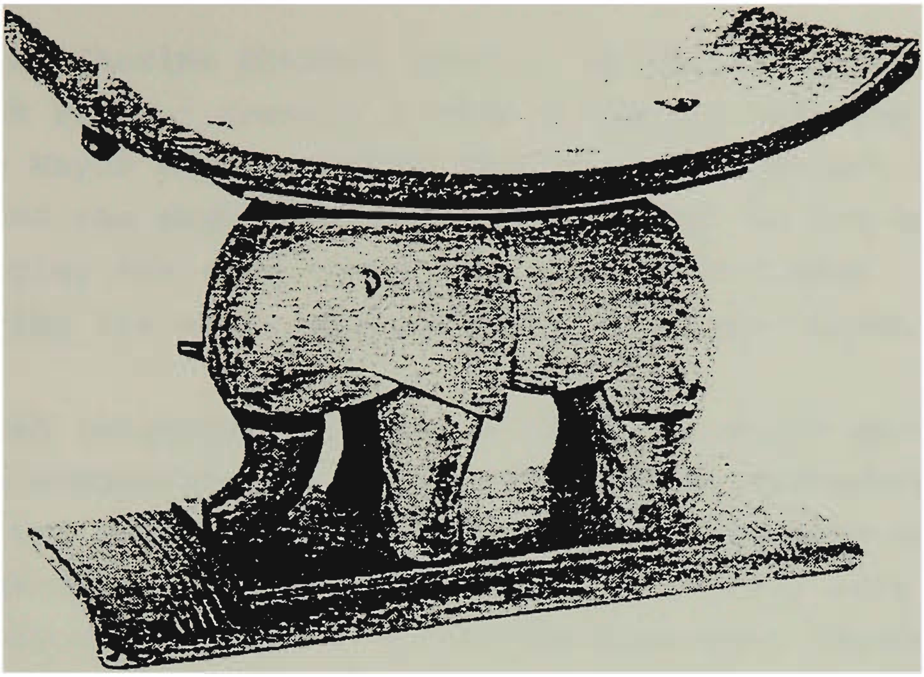

FIGURE 9. The Esono Chair (Elephant Chair), Throne of the Ashanti Kings of Kumasi, Gold Coast, West Africa. 19th Century. Reproduced from von Rotzler, W., (1969).

In all ages authority has required the enhancement of superior height - thrones rested on a platform were ascended by steps, judges were enthroned above the level of their courts, Prelates and the Masters of mediaeval Guilds also sat on thrones, and seats occupied by the Feudal Lord, his relatives and special guests were set on raised dais at one end of a great hall (after Harris, 1937). Inferior being had a physical as well as a social meaning; the lower orders in society were literally at a lower level when in the presence of their lords and masters who always looked down on them from a height from a chair of state or from the back of a horse. In the presence of Kings, Princes of the Church and great Noblemen, not only Serfs and Servants, but the lesser nobility and gentry were obliged to show their respect by kneeling (Gloag, 1964).

In England the chair has for centuries been a symbol of authority even when no chair is in use.

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The account by Charles Dickens (1837), of the election in the "Pickwick Papers" records a vote of thanks that was moved by the Mayor of Eatanswill "for his able conduct in the chair; and the mayor devoutly wishing that he had had a chair to display his able conduct in (for he had been standing during the whole proceedings), returned thanks".

In the English language there are a number of words were "chair" as a component of a phrase, has become synonymous with authority, for examples, "Papal See", "Judgement-seat", "Professional-chair". According to Mandal (1974), such phrases mainly originated in the Middle Ages when chairs were considered a status symbol associated with the ruling classes.

Chairman has become a title, invested with power, and though the chair as a material symbol has become less important, it still figures prominently in the halls, the council chambers, the board rooms and other meeting places of the upper echelon of society, while in monarchies the throne is an emblem of royal supremacy.

The traditional association of chairs with an upright, dignified bearing was not overcome until the late 17th century when the easy chair was invented. This was a starting point of the slow but continuous decline of seated dignity. By increasing standards of comfort, chair-makers and upholsterers began to change posture through design, thus unwittingly changing the character of manners, which became less formal, while dignity was relegated to Royal and offical functions (Petrie, 1922).

1.1.2 Sitting Posture

1.1.2.1 The Upright Sitting and Right Angle Limb Geometry Sitting Posture.

As early as 1737, the school regulations of the German Princedom Braunschweig-Luneburg denounced the bending of the spine in sitting as "unwholesome and injurious" (Kotelmann 1899; Bennett, 1926). According to Kramer (1981), with the start of prolonged periods of sitting in kindergarten "very often faulty positions are assumed which jeopardise the future fate of the intervertebral discs". Among an elementary school population (students ages 6 to 12 years), Mierau et al (1984) reported the prevalence of low back pain to be 22.8%. The prevalence of low back pain was found to increase to 33.3% among a secondary school population (students ages 12 to 17 years). Salminen's study (1984) of 370 Finnish school children (students ages 11 to 17 years), found that, 19.7% of the students reported current neck/or back symptoms. Of these students with current neck/or back symptoms 58.9% reported having symptoms whilst sitting. Wagenhauser (1978) also found sitting to be a major exacerbating factor among secondary school students complaining of back ache.

As education became more wide spread, interest in the design of school furniture grew. In 1888, F. Staffel constructed the school desk based on Ordnung discipline and the right angle sitting posture of Bismarck's Germany (Gloag, 1964). This postural style has also inspired modern furniture design. Industrialisation of Europe during the 19th century led to an increasing use of the chair as a sitting device to be used at work.

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In the England of Queen Victoria, commercial work was one of the few respectable occupations available for the daughters of the middle class outside of the home. (Gloag, 1964). It was important for women to look respectable even at work, and corsets and crinoline garments forced women at work to sit upright on the edge of chairs. Women had to sit upright even in easy-chairs typical of which are Victorian style ladies chairs (Gloag, 1964). Men on the other hand, could sit as they preferred and usually did so in comfortably upholstered club chairs or in typical Victorian gentlemens chairs, but they did not exercise postural preference in the presence of ladies because it was considered ill mannered to lounge around (after Gloag, 1964). Children were not spared the discipline of the right angle sitting posture and the respect in a social sense that such posture conveyed, and according to John Gloag, (1964), "children were expected to sit bolt upright, and preferably in silence".

FIGURE 10. English Women Performing Commercial Typewriting. Circa 1880. Reproduced from "the Seated Man" Homo Sedens", A.C. Mandal, 1985.

1.1.2.2 Back Pain Associated with the Design of Furniture

Bennett (1928) considered going to school to be among the most sedentary of occupations, and the place were permanents habits of sitting are formed. Shaw (1902), commented that "the desks and chairs used in the greatest number of our schools are constructed with but the slightest regard for hygienic principles". As a result of improper school seating Shaw (1902) referred to the "injurious effects as to posture, and wrong habits of carriage, which are born through life, and sadly enough come more pronounced as the years of the life increase". Shaw's comments on school a furniture are just as pertinent today as they were eighty-five years ago.

As cited by Mandal (1985), the Aarhus Architectural College, Denmark, carried out a survey in 1980 which revealed its 60% of Danish 9th class students (14 and 15 years old range students) complain of pains in the back, the neck or shoulders. The survey revealed that the students attribute blame to the furniture for such pain. From historic occupations of fisherman, hunters, gatherers and farmers, the human race has developed into predominantly a sedentry one at occupation.

The seated working position involves mainly bending the back, and this leads to the straining of the intervertebral joints, interconnective tissue of the joints and the bonding ligamentous structure, together with the musculature and its connective points on skeletal structure (Frankel and Nordin, 1978). Scientific literature indicates generally that larger numbers of the workforce are reporting back ailments, and there seems to be agreement in the literature that the strain of the anatomical components of the back has an association with the increased incidents of reporting (McKenzie, 1981). Straining the back for many hours a day by sitting in a stooped or forwards bent position is probably a significant cause of back ache (Mandal, 1985).

SEATED WORKING POSTURE

Besides the adverse physical effects of improper school seating, a study by Riskind and Gotay (1982), indicated that an individuals physical posture can have carry-over effects on motivated behaviour. In a laboratory setting at two different universities, twenty under graduate students were placed in either a slumped, kyphotic sitting posture or an upright erect sitting posture. The individuals who were previously placed in a slumped, kyphotic sitting posture later showed significantly lower persistence in a standard learned helplessness task - an insoluable geometric puzzle. These results suggested that "the self perception of being in a more slumped-over physical posture pre-disposes a person to more speedily develop self-perceptions of helplessness later, following exposure to problems that the person finds to be insoluble" (Riskind and Gotay, 1982).

"Today, the sitting position is the most frequent body structure in industrialised countries ..... we sit in the car, we sit in the train on the way to or from work, we sit most of the time at the workplace, and in the evening we go and sit in front of the television set. It can be stated without exaggeration that the sitting position is characteristic of modern times" (Grandjean and Hunting, 1977).

Unfortunately, sitting is probably also the most unhealthy of all the prolonged postures of the human body (Helbig, 1978). Whether due to poorly design chairs or work stations, musculo skeletal factors, or improper movement patterns, slouched kyphotic sitting posture dominates among observed sitting postures. However, compared to standing postures, poor sitting posture will usually always be accompanied by a greater degree of spinal flexion.

As a result, a prolonged, slouch sitting posture with a kyphotic lumbar spine has been frequently implicated as a major cause of low back pain (Keegan, 1953; Kottke, 1961; Cyrriax, 1975; McKenzie, 1981). In contrast to a lordotic sitting posture the slouch sitting posture will stress the posterior fibrous wall of the interverbral discs and the posterior ligaments of the back, as well as cause a greater pressure increase within the interverbral discs. Overall, depending on how kyphotic the sitting posture, there will be an increased potential for pain and stress to the lower back, upper back and neck (Zacharkow, 1988).

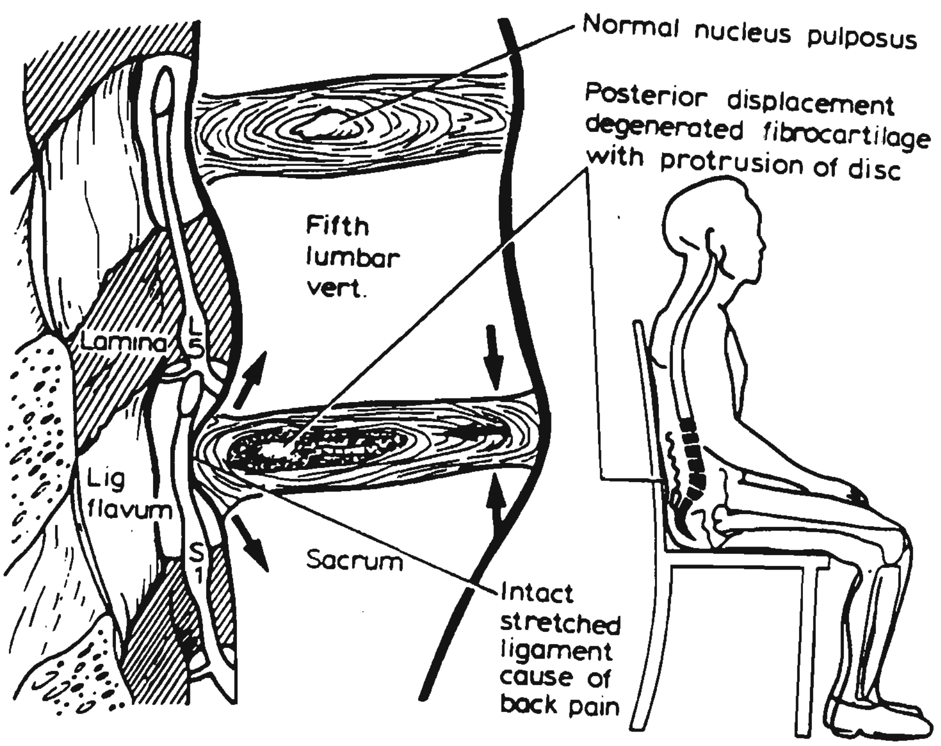

FIGURE 11. Lumbar Intervertebral Disc Straining and the Seated Position. Keegan, J.J., 1953. Published in Journal of Bone and Joint Surgery. Vol. 35-A, No 3.

This prolonged, slouch sitting posture has also been implicated as impairing both respiratory and digestive functioning (Goldthwait, 1909, 1915; Schurmeier, 1927; Bunch and Keagy, 1976; Golthwait et al, 1952). This posture can constrict the abdominal and thoracic cavities, and increase the pressure on the abdominal viscera (Zacharkow, 1988).

"In this position the chest is necessarily lowered, the lungs are much less fully expanded than normal, the diaphragm is depressed, the abdominal wall is relaxed, so that with the less support of the abdominal wall, together with the lowering the diaphragm, the abdominal organs are necessarily forced downwards and forward" (Goldthwait, 1915).

The sitting position is basically unstable without conditional external support. This is because the ischial tuberosities, with their rounded shape resembling the rockers of a rocking chair, provide only a linear base of support (Meyer, 1873). Also, in the sitting position the hip joints are in an intermediate position and the trunk cannot be locked relative to the thighs by ligamentous restraint (Akerblom, 1948; Meyer, 1873; Coe, 1983).

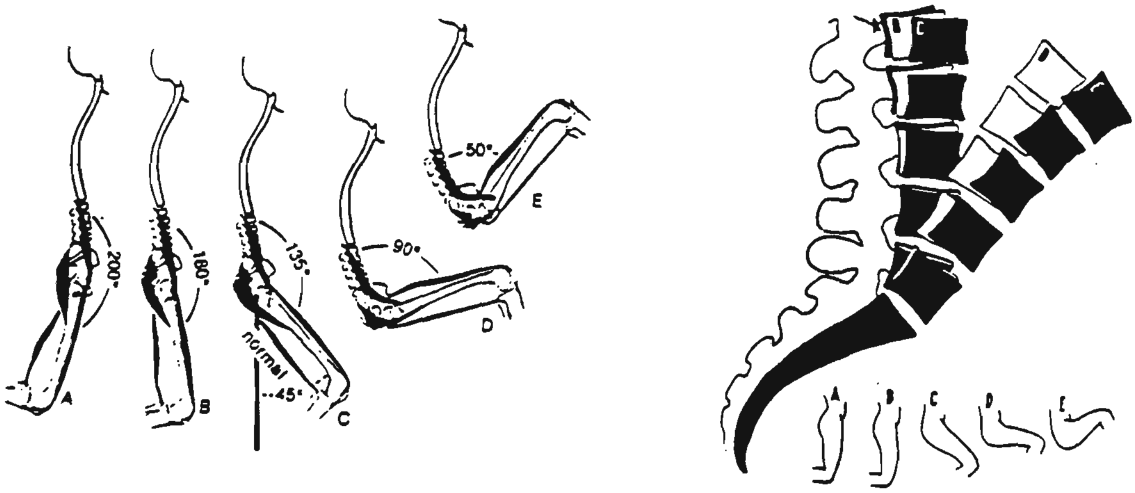

FIGURE 12. The Positions of the Skeletal and Muscular Structures Governing Movements of the Back, Measured from a Relaxed, Horizontal Position. Published in Journal of Bone and Joint Surgery, Vol 35 - A, No 3. Keegan J.J., 1953.

As a result, muscle activity is necessary for fixation of the trunk when sitting without additional stabilisers. A common misconception, is to consider sitting in a chair as a static activity as opposed to dynamic activity. According to Branton (1966), the sitting body is "not merely an inert bag of bones, dumped for a time in the seat, but a live organism in a dynamic state of continuous activity". Branton's (1969) mechanical model of the sitting body from the waist down depicts 4 variations of freedom to move, even with the feet planted firmly on the floor, and they are:

i. rocking of pelvis over ischial tuberosities;

ii. flexion and extension at the pelvic-femoral joint;

iii. flexion and extension at the knee joint;

iv. flexion and extension of the ankle joint.

In the sitting posture, the hip, the knee and ankle joint are near the mid point of their range of motion, and therefore they are in the state of maximum mobility (Zacharkow, 1988). Branton (1966, 1969), mentions that even if an individual appears to sit still, his body is continuously moving. The freedom of the pelvis to move, which will be present in all sitting postures when the upper sacrum is not supported by a backrest, will result in "continuous hunting" or relatively fast oscillary movements of the pelvis rocking over the ischial tuberosities.

Therefore, Branton (1966) hypothesised that there is a continual need for postural stability when sitting, so that the seated person "spontaneously takes up such postures as will allow her/him to sit stably, while relieving her/his brain and muscles from greater exertion than would be necessary otherwise".

"If this seat does not allow postures which are both stable and relaxed the need for stability seems to dominate the need for relaxation, and postures are adopted which rigidify the body internally in compensation." In other words, if the seat features fail to stabilise the body, the person must stabilise herself/himself, eg. by crossing the legs, or by supporting the head on her/his hand. This maybe at some extra cost in muscle work (after Branton, 1966).

Dempster (1955) compared the dynamic body to an open chain system of links as they rotate about the joint centres. He described how certain joint motions may be stabilised:

> "The fingers of the two hands may be interlocked to interconnect the right and the left upper limb links; the legs may be crossed for seated stability; the arms may be crossed or placed on the hips. In such actions as these, temporary approximation to closed chains are effected.
>
> Link chains may be cross-connected as in crossing the knees (viz, pelvis and right and left thighs) or in placing the hand on the same or opposite shoulder. To the extent that these temporary closed chains approximate a triangular linkage, there is a degree of stability imparted even without muscular actions, but this is still approximate because of the interposed soft tissues. The closer the links approximate a closed triangular, or pyramidal pattern the less muscles are called upon for stabilising action at joints. One may recognise many rest positions involving this principle ... - crossed arms, hands in pockets, or such sitting positions as crossed knees, ankle on opposite knee, elbow on knee, or head in hand". (Dempster, 1955).

Temporary closed chains may also include certain environmental objects. The most commonly observed example is when the arms are supported on a desk (Meyer, 1873).

Pressing the knees as a closed chain of body segment activity was examined by Akerblom (1948), when he used an example of a chair with inclined backrest, horizontal seat, and a slippery seat cover. When the experimental subject leant against the backrest, there was a force tending to push the buttocks forwards on the seat, and this action slowly ejected the sitter. Using Branton's mechanical model of sitting (1969), there will be four variations of motion observed as the individual buttocks slide forward on the seat, with feet firmly on the floor -

i. Upward rotation of the pelvis (rocking over the ischial tuberosities);

ii. Extension at the hip joints;

iii. Flexion on the knee joints;

iv. Dorsiflexion at the ankle joints.

Another commonly observed closed chain-position would involve stretching the legs forward into extension. This posture will lock "the knees and the ankles, and the lower extremities become rigid posts pushing against the floor for forward slide (Branton, 1969)."

SEATED WORKING POSTURE

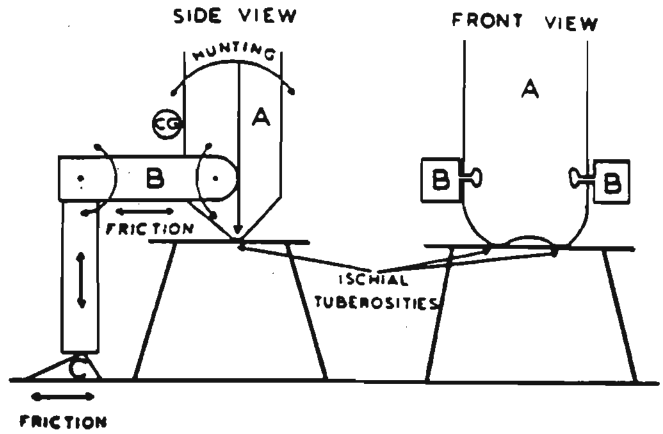

FIGURE 13. Branton's Mechanical Model of the Sitting Body from the Waist Down.
A Trunk; B. Femur; C. Foot;
C.G. Center of gravity of sitter.
Hunting = oscillatory movements of the pelvis rocking over the ischial tuberosities.
Reproduced from Proceedings of the Symposium on Sitting Posture, 1969.

Unfortunately, and contrary to the observations and experimental reports of biomechanists, work physiologists and anatomists about characteristics of seated working posture, authorities from most parts of the world have an opinion that right angled lower and upper limb geometry of sitting with an upright trunk position is an ideal one.

There is no explanation from American, European, English or Scandinavian authorities who have established and promoted such postural modelling, of where the idea for such modelling came from, and no connection with scientific research or development has been established by the publishers.

The postural models set up by these authorities establish people sitting with joints at the hips, knees, ankles and elbows all making right angles. While this appears 'architectural' and is anthropometrically presented by linear dimensions and geometric angles, with the subjects sitting with a concave curve in the low back and staring into space, it is unlikely that anyone actually sits or works in this way (Mandal, 1985).

SEATED WORKING POSTURE

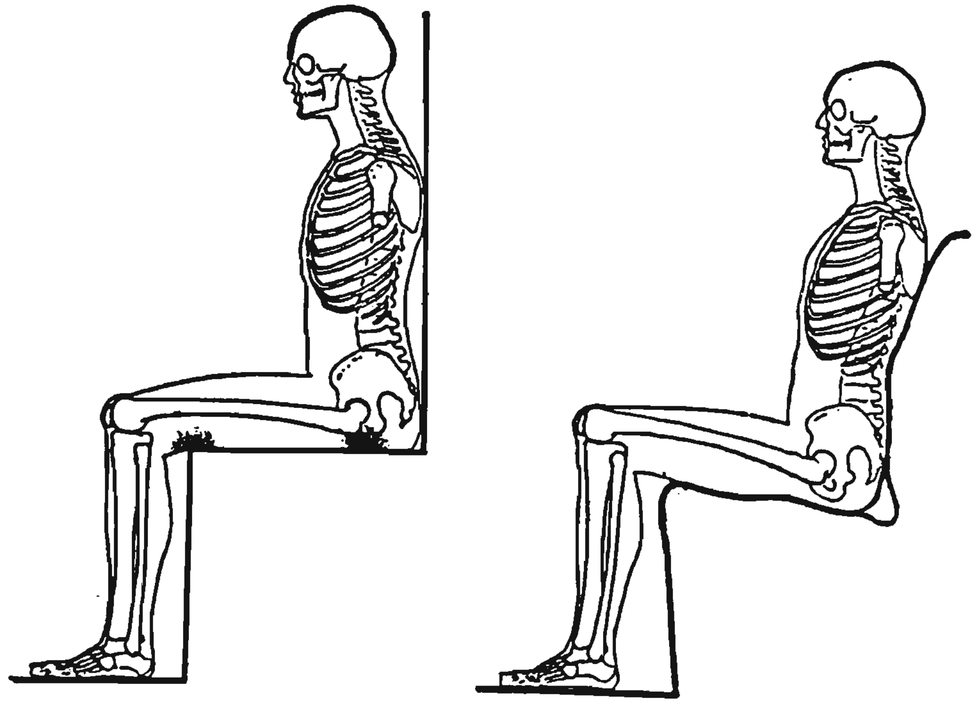

FIGURE 14. Left. The back is completely vertical, with the result that the head is thrown off balance, the back is left unsupported, and the sitting posture becomes penitential as the flat seat is not shaped to the body or tilted, and is the wrong height from the floor.

Right. The seat is the correct height from the floor, and, like the backrest is shaped to the contour of the back. The seat is slightly inclined to allow gravity to assist a comfortable reclined sitting posture.

Adapted from "Furniture from Machines", after Logie, G., 1947.

SEATED WORKING POSTURE

At school, the right-angled and sitting upright posture taught to students appears originally to have been a salutatory one and was only adopted specifically on occasions upon visits by head teachers or other dignitaries, whereas the working postures depicted in the International Standard Organisation (1978), European, Scandinavian, American, and English and other postural models appear to have been adopted from the Pharaoh's divine position of sitting as depicted in the stone sculptures of the Egyptian civilisation (examples, Kephren, fourth dynasty - Old Kingdom 2664 - 2155 BC covering Dynasties III - VIII and the Colossi of Memnon, statuary remains of the mortuary temple of Amenhotep III - 1417 to 1379 BC, eighteenth Dynasty - beginning of the New Kingdom), and representing the purely symbolic work done by the rulers of Egypt (after Mandal, 1985).

In commenting about the Danish postural models based on the "German Square" principles and known as DKI and DK2, Mandal (1985) stated that "you take a skeleton and seat it on a chair. If that is a model you make a nice drawing and - abrakadabra - you have the prescription for how living people must sit".

Mandal (1985) also commented that a skeleton has greater advantages over living humans when it comes to sitting "correctly" because:-

i. It can sit and stare into space all day;

ii. It has no tendons or muscles to restrict movement in the hip and other relevant joints;

iii. It has a bent but flexible bar system through its spinal structure to replace the natural ligamentous structure and cental nervous system, so it can sit in the same lumbar curve normally used in the standing position.

Further, Mandal (1985) commented that in order to have a satisfactory overall appearance, the spinal column of the standing person has been taken, and the legs for a sitting person have simply been drawn on to it. Thus, without the slightest regard for the humans actual anatomy in the seated position, a new human form described in line work has been contrived to fit available furniture.

The same type of linear depiction, more over, forms the basis for international standardisation of furniture, for examples the International Organisation for Standardisation, 1978; the Commitee European de Normalisation, 1978; and is also used for training furniture designers for examples United States of America model, US, 1974, (revised 1981), and the Scandinavian model S, 1983.

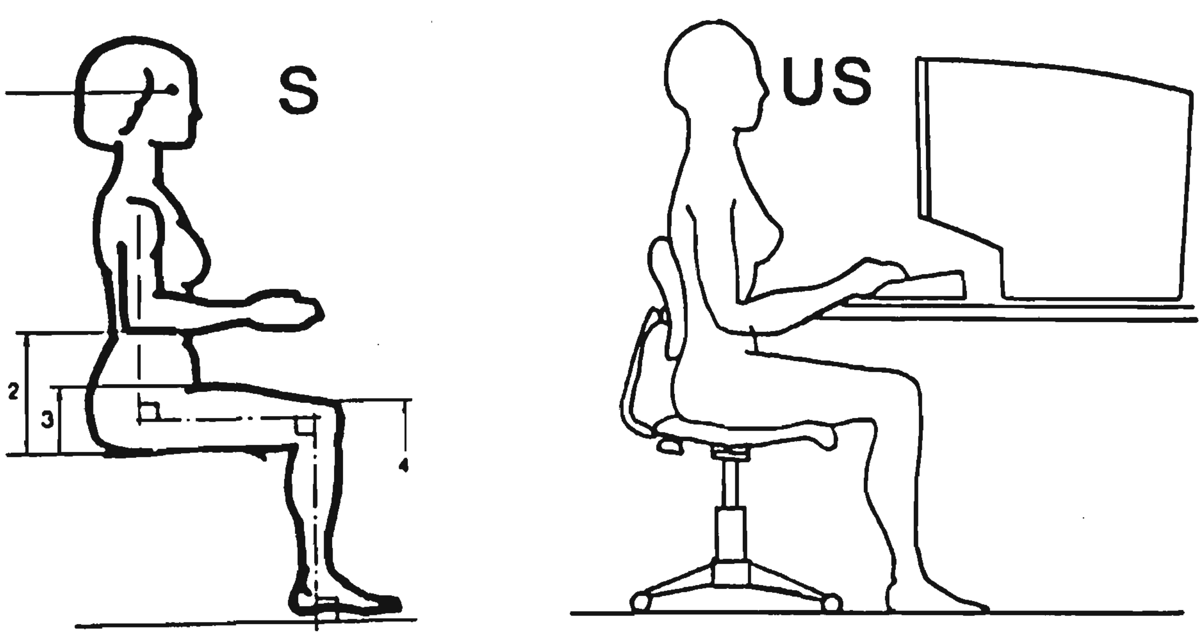

FIGURE 15. Scandinavian Postural Model S, 1983. US Postural Model for Screen Based Equipment, 1981. (Based on US MIL-STND-1472 B, 1974).

1.1.2.3 Training to Achieve the Ideal/"Correct" Sitting Posture in Subjects.

Mandal (1985) cites that in the Gentofte municipality of Copenhagan, Denmark, most schools provided pupils with about 90 short lessons in correct sitting technique "over a period of approximately 5 years." The result of this, probably the greatest teaching effort in correct sitting technique in the world, has been that pupils all adopt slumped-over kyphotic back postures and unbalanced asymmetric postures to see, read and write whilst performing school work. Mandal (1985) believes that the leading reason for bad working position lies in the fact that children and young people have an average optimal visual distance for reading approximately 300mm, and as their work tables are relatively low (approximately 727mm/28.5 inches high) - being almost at the seated knee joint height for the taller pupils, they must consequently bend there backs to anatomical limits to get their eyes to reasonable reading distance with hard copy.

Yet based on their studies from 1973 until 1978, both Danish and Swedish authorities came to quite a different conclusion. They proposed in 1978 that the International Organisation for Standardisation (IOS) should reduce the desk height by 2½ inches (approximately 64mm) for most pupils and for shorter stature pupils the reduction should be by as much as 4.5 inches (approximately 115mm). Yet, it is clear that the student group sitting at lower tables as described by Mandal (1985) will flex their backs or their hip joints even more so than they currently did at the time of the survey. Alternatively, the option would be to pick up the visual material in the hands and use the arms lectern - like to reduce visual distance for focus and accommodation and to reduce muscular and skeletal fatigue about the cervical, thoracic and lumbar spines together with the activity of the greater trochanter of the hip.

SEATED WORKING POSTURE

Samuel A. Eliot, a member of the Boston School Committee, in 1833 stressed that "its the duty of parents and those who act with them to take care that the school shall be a place where the children may acquire the use of their intellectual faculties without having there physical organisation disturbed or there vital powers debilitated by a constrained position".

Hartwell (1895) determined that elementary school could be classified as a sedentary occupation for 84% to 88% of the school period. An english investigation by the Department of Education and Science (1976) found that students tended to use the desk and chair more for both working and listening as they grew older. Among the 16 to 18 year olds for example, 73.3% of the school period involved using both desk and chair.

Bennett (1925, 1928) made two detailed studies on school posture and these were based on 4,637 individual observations in Chicago elementary schools and high schools. Observations were based on the spinal profile, which was classified as either erect or slumped (kyphotic). The slumped posture involved either a forward slump, a reclined slump, or a slumped spinal profile with the students sitting position being fairly vertical. Results showed that 59% of all observations involved a slumped posture (kyphotic rearward or forward). The worst postures (65% slump) were in reading and writing activities. Bennett gives no definitive angles of trunk, limbs or head to qualify the slumped postures observed in the two studies.

SEATED WORKING POSTURE

An investigation reported by Watzka (1969) involved observations on 42-girls and 42-boys, of mean age 17.2 years, who were in the upper classes at two secondary schools in England. Three aspects of postural behaviour most frequently observed involved:-

i. sitting without support from the backrest;

ii. trunks slumped forwrds;

iii. both arms leaning on the desk.

This combined posture appeared to be imposed by the necessity to write on a horizontal desk. However, writing was observed to occupy approximately 30% of the total time whereas of this desk-supported posture was observed to occur between 65 to 80% of the total time.

Watzka et al (1969), made 2798 observations on students' sitting behaviour in auditorium seats during lectures. Approximately 60% of the observed time was spent writing by the students, approximately 28% of time was spent listening. Students were observed to lean against the backrest approximately 32% of the time. Over 80% of the time, students rested there lower arms on the writing surface.

The German orthopaedic surgeon, Professor Hanns Schoberth (1962) performed basic research into childrens working positions. In the ordinary, relaxed sitting position he found among 1,035 children not one who preserved the lumbar curve. The children of the sample were asked to sit up, that is with conscious muscular tension, and he measured a mean lumbar curve in the sample group of 30.5 degrees.

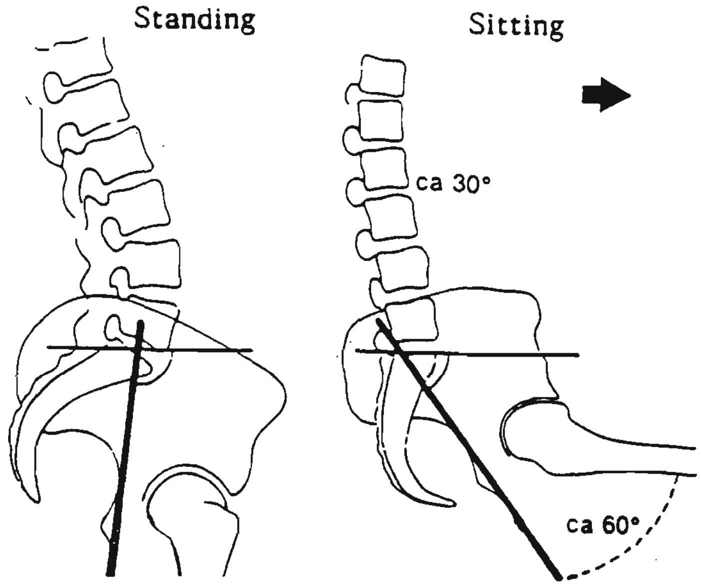

FIGURE 16. Rotation of the Pelvis from the Standing and Sitting Positions. Schoberth, H., (1962). The hip bends slightly less than 60^{o} when moving from the standing to the sitting position. A tangent to the ischial tuberosities has been drawn through the leading edges of the two large convexities in the rear edge of the sacrum (insicura isciatica major and minor).

1.1.2.4 Anatomy of the Sitting Position

The evolution of man's erect biped stance from a quadruped posture has been "marked by a narrowing of the bases of support and a progressive elevation of the centre of gravity of the body as a whole. Both work against stability" (Hellebrandt and Franseen, 1943). With a centre of gravity placed high above a relatively small supporting base, gravity is the major deforming force affecting man's stance (Zacharkow, 1988).

SEATED WORKING POSTURE

In the idealised erect resting posture when standing, a line of gravity is considered to be located in the middle line between the following points (Basmajian, 1978; Woodhull et al 1985):-

i. The mastoid processes;

ii. A point just in front of the shoulder joint;

iii. A point just behind the centre of the hip joints;

iv. A point just in front of the knee joints;

v. A point approximately 5 to 6 centimetres in front of the ankle joints (Woodhull et al, 1985) Klausen, 1965; Hellebandt et al, 1938).

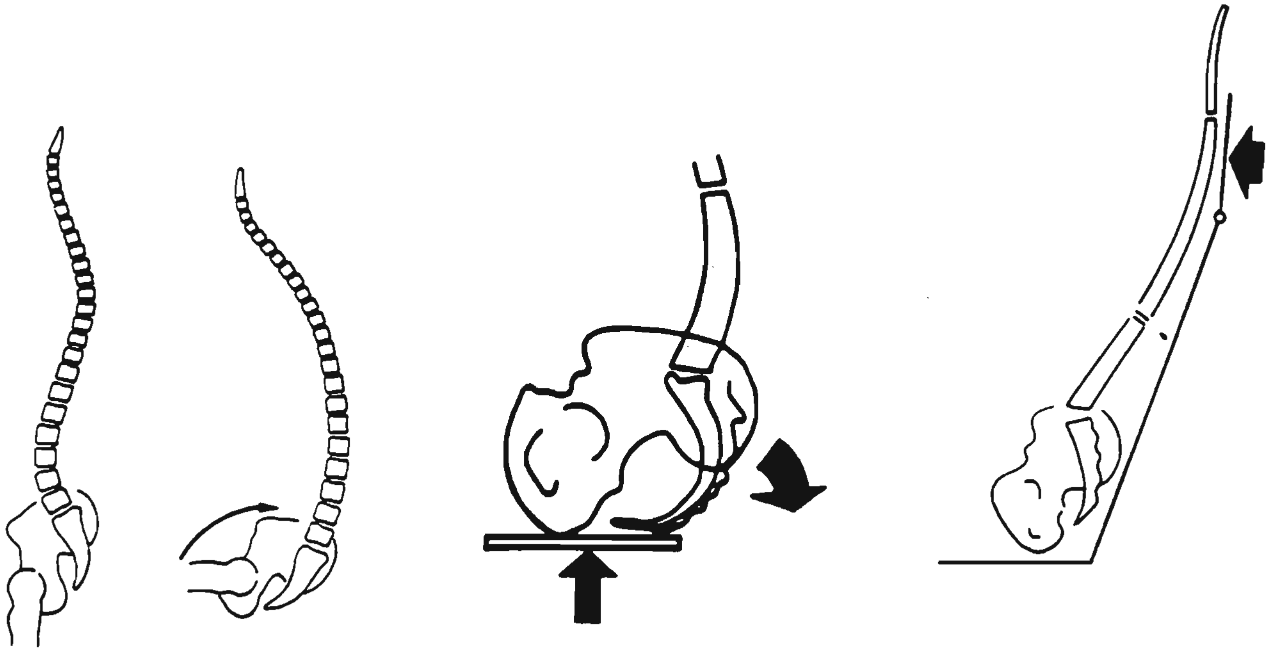

FIGURE 17. Idealised Erect Resting Posture when Standing and Sitting. Adapted from Andersson, B.J.G., Ortengren, R., Nachemson, A., and Elfstrom, G. (1974).

When changing from a standing position to a relaxed, unsupported sitting position, the pelvis rotates backward and there is a subsequent change of the lumbar lordosis into a kyphosis.

If the major weight bearing area on the seat is posterior to the ischial tuberosities, there will be localised pressure over the coccyx. Where there is concavity to the backrest, the result will be difficulty in maintaining contact with the lumbar support with poor pressured distribution over the seat and backrest.

The muscular activity required at the major body joints to achieve such idealised standing posture is required of the ankle joint, the knee joints, the hip joints and the spine.

To understand the problems of the sitting position it is necessary to study the anatomical changes when a person moves from standing to a single position. Mandal (1985) comments that medical and paramedical training has never included more than "normal anatomical position which corresponds closely to the military position of attention - an unusual interest since this is not a position anyone would naturally choose to stand in".

Medical knowledge of human anatomy evolved from dissections carried out at the beginning of the 16th Century in Europe, the time when the first serious attempts were made to find out how human insides were structured and how the physiological process worked (Mandal, 1985; Keegan, 1953; Akerblom, 1948). It is reported by Mandal (1985) that during the Renaissance period in England dissections were carried out in public as form as entertainment or as a form of medical learning, by the barbers. The group formed the college of Barber-Surgeons and a leading Barber-Surgeon John Banister is shown illustrated in Mandal's treatise (1985) at work teaching anatomy in 1581. Mandal states that the bones, ligaments and muscles of the body were depicted, and such drawings have later been rotated 90^{o} degrees to demonstrate what is called "the normal anatomical position". The position of a body on a mortuary table was viewed as normal, and interest in the position that most humans adopt for most of the day - the sitting position, has been generally ignored.

SEATED WORKING POSTURE

FIGURE 18. Barber-Surgeon John Bannister at Work teaching Anatomy in 1581.

Reproduced from "the Seated Man, homo Sedens". A.C. Mandal, 1985.

A small number of internationally respected experts mainly from the medical profession and predominantly orthopaedic surgeons, have in the past 30 or so years shown considerable interest in the anatomy of the sitting position. (Akerblom, 1948; Keegan, 1953; Schoberth, 1962).

When an individual goes from a standing to relaxed, unsupported sitting position the pelvis rotates backwards and there is a subsequent change of the lumbar lordosis into a kyphosis. This pelvic rotation is due is part tension of the hip extensors as the hips are flexed (Keegan 1953, 1964; Carlsoo 1972).

However, the major pelvic rotation upon sitting does not begin until after the buttocks are resting on the seat. This backward rotation of the pelvis is mainly due to the posterior rocking over the ischial tuberosities that occurs as the gravity line trunk comes to line posterior to the ischial tuberosities (Akerblom, 1948).

The amount of backward pelvic rotation that occurs when going from a standing to a relaxed unsupported sitting posture has been investigated by Andersson et al 1979 and Akerblom (1948). Based on data from 80 individuals age range from 21 to 44 years, Andersson etal (1979), reported average pelvic rotation of 28 degrees. Akerblom (1948) reported an average pelvic rotation of 35 degrees, from a study involving 32 individuals. Schoberth (1969) stressed that the shape of the spine in "sitting" depends directly on the position of the pelvis.

Even though the thighs have changed from a vertical to a horizontal position when going from standing to a relaxed, and supported sitting posture, the actual hip flexion that occurs is not 90 degrees. It is not unusual to find that only 50 to 60 degrees of actual hip flexion in a relaxed unsupported sitting posture (Akerblom, 1948); Schoberth, 1962; Carlsoo, 1972). Lumbar flexion or kyphosis that occurs in relaxed, and supported sitting is necessary in order for the individual to assume an upright posture after the pelvis has rotated backwards (Straaser, 1913; Akerblom, 1948). This flexion involves mainly the lower three lumbar segments, (Andersson et al, 1979, Schoberth, 1962; Akerblom, 1948).

Based on data from 25 individuals, from age range 5 to 41 years, Schoberth (1962) found an average total flexion of 30.4 degrees from lumbar segments L III - L IV, L V - S 1 when going from a standing to a relaxed, unsupported sitting position. Overall, Andersson et al. (1979) found an average decrease in the lumbar lordosis of 38 degress of which 28 degrees was due to pelvic rotation.

SEATED WORKING POSTURE

The relaxed kyphotic sitting posture described is not the only unsupported sitting posture capable of being assumed by the individual. For example, one can counteract the backward pelvic rotation and lumbar kyphosis with an active tightening of the erector spinae musculature, resulting in a either a straight or lordotic sitting posture (Keegan, 1953).

The actual unsupported sitting posture assumed depends on various factors such as the mobility of the hips, the mobility of the spine, the individuals habitats and the individuals fatigue level (Zacharkow, 1988).

Schoberth (1962), describes three basic unsupported sitting postures differentiated by the centre of gravity of the trunk and the percentage of body weight transmitted by the feet to the floor. These three sitting postures are most easily observed when sitting on a flat surface without a backrest, feet flat on the floor and with thighs horizontal and the lower legs vertical.

In the middle position, the centre of gravity of the trunk is above the ischial tuberosities, and the feet transmit approximately 25% of the body weight to the floor. When sitting relaxed in this posture, the lumbar spine is either in a slight kyphosis or straight. However, with an active contraction of the erector spinae musculature, a more bright middle position will result, with the lumbar spine changing to either straight or lordotic. The more lordotic the upright posture the more the pelvis will rotate forwards with corresponding anterior shift of the trunk's gravity line.

In the anterior position, centre of gravity of the trunk is anterior to the ischial tuberosities and the feet transmit more than 25% of the body weight to the floor. This forwards leaning posture can be assumed from the middle position in either of 2 ways (after Andersson et al, 1975) -

i. with little or no pelvic rotation but maximum flexion of the spine (after Andersson et al, 1975);

ii. by a forward rotation of the pelvis, keeping the lumbar spine in either slight kyphosis/or in lordosis.

The degree of straightening lordosis of the lumbar spine in this posture would depend on several factors including the extent of conscious activation of the erector spinae musculature and the degree of hip mobility.

In the posterior sitting position, the centre of gravity of the trunk is above or behind the ischial tuberosities, and the feet transmit less than 25% of body weight to the floor. Posterior position is obtained from the middle sitting position by a backwards rotation of the pelvis, resulting in a kyphosis of the lumbar spine (after Andersson et al, 1975). In this posterior sitting position, the greater the backwards rotation of the pelvis, the greater the posterior shift of the trunk's gravity line behind the ischial tuberosities.

The shape of the lumbar spine is usually the same in the most frequently observed anterior and posterior sitting positions. The lumbar spine is in a marked kyphosis and the erector spinae muscles are relaxed, with the spine being supported by the posterial ligaments (Akerblom, 1948; Carlsoo, 1948; Floyd and Silver, 1955).

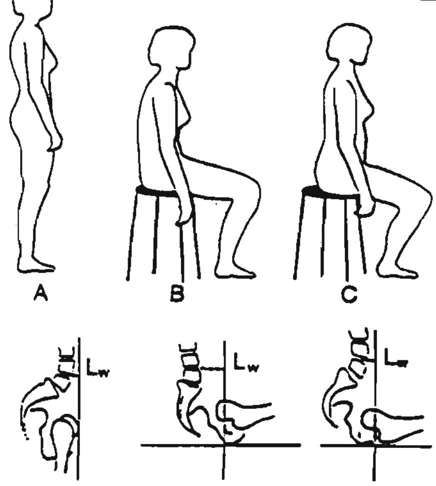

FIGURE 19. Pelvis Rotation of the Lumbar Spine Moving from the Standing to the Sitting Position.

Akerblom, B., 1948.

1.1.2.5 Physiological Matters and the Sitting Position

The lumbar intervertebral disc pressure is considerably lower in standing compared to unsupported sitting postures (Andersson et al, 1974c, 1975; Fiorini and McCammond, 1976; Okushima, 1970). Of all the unsupported sitting postures the intervertebral disc pressure is the lowest in the lordotic upright posture and the highest in the kyphotic anterior sitting posture (after Andersson et al, 1974d).

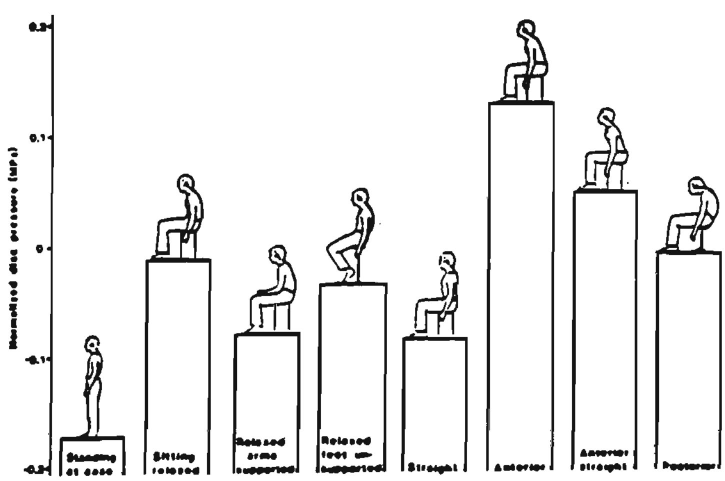

FIGURE 20. Lumbar Intervertebral Disc Pressures in Various Supported and Unsupported Postures.

After Nachemson, A. and Elfstrom, G.: Intravital Dynamic Pressure Measurements in Lumbar Discs. Journal of Rehabilitation Medicine, Stockholm (1970).

SEATED WORKING POSTURE

According to Zacharkow (1988), the following factors are considered responsible for the change in disc pressure from the standing to the unsupported sitting position.

1. Compared to erect upright standing, in relaxed unsupported sitting, the pelvis is rotated backwards with a flatening or reversal of the lumbar lordosis. The gravity line of the upper body, already anterior to the lumbar spine in erect standing, will shift further forwards. This results in a long lever arm for the force exerted by the weight of the trunk, producing an increased torque in the lumbar spine. If the trunk is bent forwards, this torque will increase even further (Lindh, 1980; Frankel and Nordin, 1980). With active contraction of the erector spinae musculature and a more upright sitting posture, the intervertebral disc pressure will be reduced as compared to a relaxed middle or posterior sitting position. This is because as the backward pelvic rotation and lumbar flexion are reduced, the lever arm for the force exerted by the weight of the trunk will be shortened (Lindh, 1980).

2. In the normal lordotic standing posture, the intervertebral compressive forces are shared between the discs and the facet joints. Approximately 16% of this compressive force is carried by the facet joints when standing (Adams and Hutton, 1980). The facet joints will not take any of this load in kyphotic sitting postures, resulting in higher compressive loads on intervetebral discs. (Zacharkow, 1988).

3. Further reason for the increased intervertebral disc pressure with unsupported kyphotic sitting postures would be the greater deformation of the disc in these postures, compared to the normal physiological shape of the disc in lordosis (Andersson et al, 1974c).

4. In addition, a drop in the normal resting intra-abdominal pressure when sitting with lax lower abdominal muscles would also increase the spinal loading and disc pressure (Frymoyer and Pope, 1978; Armstrong, 1965). This is an important factor that is often overlooked.

All unsupported sitting postures are basically unstable without further external support (Meyer, 1873). This is due to pelvic instability inherent in unsupported sitting (Coe, 1983). The hip joints are in an intermediate position, and the "upper part of the body cannot be locked relative to the thighs by any form of passive checking mechanisms" (Akerblom, 1948). The balance is therefore maintained by the muscles of the hip joint and trunk.

When, in the middle sitting position with the centre of gravity of the trunk directly over the ischial tuberosities the position is one of unstable equilibrium since the ischial tuberosities, with their narrowed, curved surface, provide only a linear support (Helbig, 1978; Meyer, 1873). An individual can slump into a posterior sitting position, which will relax the back musculature, (Schoberth, 1962; Karlsoo, 1962; Andersson et al 1974a). Stability will be improved due to the additional supporting service provided by the coccyx, the sacrum, and the posterior buttocks. With the gravity line now shifted the posterior to the ischial tuberosities, the psoas major will become the main antigravity muscle (Keagy et al, 1966).

Leaning back more than a few degrees without external support (such as a backrest or backward placement of the hands) becomes a very unstable posture since there is minimal weight bearing on the legs. To maintain such a posture also requires increased activity from the rectus abdominis muscle and the neck musculature (Asatekin, 1975; Cotton, 1904). Stretching of the arms and legs forwards can also help the individual to barely maintain this posture (Meyer, 1873; Akerblom, 1948).

In a lordotic upright sitting posture, the gravity line of the head passes anterior to the cervical spine, thereby requiring slight to moderate activity of the poterior neck musculature to counteract the tendency for the head to incline forwards (Steen, 1966).

With a slumped, kyphotic sitting posture, the gravity line of the head will pass further anterior to the cervical spine, and there will be an increased demand placed on the poterior neck musculature (Jones et al, 1961; Gray et al, 1966; Bunch and Keagy, 1976). An increase in neck muscle activity will also be required to keep the head erect and gaze horizontal (after Bunch and Keagy, 1976). The greater the slump and the thoraco lumbar kyphosis, the greater will be the forward thrust of the head, resulting in a marked increase in activity from the upper trapezius and other posterior neck musculator (Gray et al, 1966). A greater than 50% increase in muscle tension at the back of the neck has been reported when going from an erect sitting posture (Gray et al, 1966).

The alteration in the shape of the cervical spine in a slumped, kyphotic sitting posture would probably resemble a contour described by Inglemark (1942). From radiological examinations of 16 patients with pain in the middle and lower neck and trapezius muscle tenderness, Inglemark, (1942) found an absence of the normal cervical lordosis at the C IV C VII level, and hyperlordosis above the C IV level.

SEATED WORKING POSTURE

Compared to a middle sitting position (upright and erect trunk posture), the stability is improved as the individual leans forward into an anterior position. This is due to the increased supporting surface provided by the upper posterior thighs and the increased body weight of the feet with this posture. However, without external support, as the gravity line is shifted anterior to the ischial tuberosities, the erector spinae and hip extensor muscles must contract prevent trunk from falling forwards, (Cotton, 1904, Akerblom, 1948; Schoberth, 1962; Andersson et al, 1974a). With extreme spinal flexion, the erector spinae will relax and only hip extensor activity will be required to maintain this posture (Akerblom, 1948; Floyd and Silver, 1955; Floyd and Roberts, 1958; Carlsoo, 1972).

If there is external support, the erector spinae and hip extensor muscle activity can both be relieved, and the anterior sitting position can become the most stable (although not physiologically the most beneficial unsupported sitting posture). Examples of such external support are as follows (Meyer, 1873,) -

1. The hands and forearms are supported on the thighs;

2. The anterior trunk is supported by the edge of the table;

3. The arms are supported on a table.

As the gravity line of the head is also move anterior to the cervical spine with the anterior sitting postures, there will be also be an increased stress placed on the posterior neck musculature.

1.1.2.6 Studies of Seated Working Posture

Besides the various types of visual display work, continuous or dynamic postures are also characteristic of other office jobs such as full-time typing the operating of accounting machines, and reading writing tasks traditionally conducted in commercial enterprise (Hunting et al, 1981; Maeda et al, 1982; Grandjean, 1984c). For example, Maeda et al (1982) described the typical posture of an accounting machine operators as "a continuous sitting posture of the neck and head tilted forward and to the left with some rotation of the head to the left to orient the visual line to the receipts, the left hand being used to turn over the receipts, and the right hand being rapidly used to operate the numerical keyboard".

The most frequent musculoskeletal complaints of visual display terminal (VDT) operators have been found to involve the neck, neck-shoulder region and back (Cakir et al, 1979; knave, 1983). The arms, wrists and hands are also sites for musculoskeletal complaints (Arndt, 1982, 1983; Sauter et al, 1983, 1984; Smith, 1984a; Ostberg, 1979; Ong et al, 1981; Cakir, 1980; Elias et al, 1983; Kukkenel, 1984). Musculoskeletal complaints have even been reported among VDT operators with minimal job dissatisfaction and minimal psychosocial stress (Smith, 1985).

However, it is important to realise that the musculo - skeletal complaints associated with the use of VDT's and other office machines have usually been found in work settings characterised by poor work station design and poor sitting postures (Hunting et al, 1981; Ong et al, 1981; Starr et al, 1982; Maeda et al, 1982; Sauter et al, 1983).

SEATED WORKING POSTURE

Factors such as non-detachable keyboards, an increased forwarding inclination of the head, and the lack of proper arm and back support have been corelated in the studies aforementioned, with an increased incidence of musculoskeletal complaints. Also, poor head posture the work station may also reflect the individual's chronic sitting and standing postural habit patterns. Neck pain and headache may also result from the awkward head and neck posture observed when VDT operators rest a telephone receiver between the neck and shoulder, while handling customer enquiries as they type at the keyboards (Travers and Stanton, 1984; Travell, 1967).

An issue involves the conflicting recommendations that are given in various VDT articles, brochures, books, international standards, and those such as issued in the United States of America, Europe, Great Britain, Australia and Scandanavia, in regards to proper sitting posture, arm posture, desk height, keyboard slope, etc at the VDT workstation.

Upon closer examination, it can be realised that a complex inter relationship exists among the observed VDT workstation posture and other workstation factors including -

- the inclination and height of the chair backrest;
- the keyboard slope and the height from the floor;
- the use of an inclined document holder;
- the use of forearm supports and the size of such supports;
- the availability of seat tilt and the range of tilt in the seat of the chair;
- the hand links of the operator. (after Zacharkow, 1988).

SEATED WORKING POSTURE

The international viewpoint in VDT workstation recommendations is based on a sitting posture with the trunk in a vertical position, forearms horizontal and the upper arms vertical. A chair with a low backrest, high enough to provide lumbar support, is considered adequate for this VDT sitting posture (Cakir et al, 1980). To achieve this posture, it is also stressed that the keyboard should have a minimal thickness, along with very little slope usually close to 5 degrees. (Knave et al, 1983).

After a short time, due to the inherent instability of a vertical trunk posture, the operator must seek further stability from the workstation, (Grandjean et al 1983a). A forward leaning posture may be adopted, where the operator can obtain better trunk support by resting the arms on the desk. A very low back rest height and the lack of an inclined document of both facilitate a forward leaning posture. There are also certain VDT tasks such as customer service counter work, were the operator needs to lean forward to the customer. (Launis, 1984; Grandjean,1984c).

In the majority of VDT tasks, the operator does not have to lean forwards towards a client. In such job settings completely different forearm posture has been frequently observed. Even on chairs not designed for reclined postures the VDT operators have been observed to lean backwards on their chairs (Grandjean et al, 1983a). In addition to leaning the trunk backwards, commonly observed arm postures do not involve having the upper arms vertical and the forearms horizontal. Instead, the shoulders are usually flexed from 0 to 30 degrees, and the forearms are elevated from 5 to 30 degrees (Arndt, 1982, 1983).

SEATED WORKING POSTURE

In field studies by Granjean et al, 1983a) with an adjustable VDT workstation, the majority of VDT operators at data entry work in conversational terminals preferred a backward leaning trunk posture of 10 to 20 degrees from vertical. The "mean body posture" of the VDT operator included a 14 degree trunk inclination, with the forearms elevated 14 degrees, and the shoulders flexed 23 degrees. As Grandjean (1984c), commented, "many VDT operators in offices disclose postures very similar to those of car drivers. This is understandable - who would like to adopt an upright trunk posture when driving a car for hours?".

According to Grandjean (1984c), the backward leaning trunk posture is the basis for all the other adopted postural elements of the VDT operators (including the flexed shoulders with inclined forearms and the slightly opened elbow angles beyond 90 degrees. It is therefore important to detail several inter-related workstation features that will help facilitate this backward leaning posture with elevated arms (Zacharkow, 1988) -

1. A backward leaning trunk posture will be facilitated by a chair with a high back rest providing upper back support, along with an adjustable back rest inclination that can be fixed at any angle by the operator. Pressure should be avoided, over the outer part of the scapulae and the shoulders (Taylor, 1917).

2. A major reason for the elevated forearm posture probably relates to the slope of the keyboard. There will be optimum efficiency of arm and wrist movements with the forearm angle matching the keyboard angle (Arndt, 1983). Therefore, with greater keyboard slopes, one will probably observe a greater elevation of the forearms (Arndt, 1983).

3. With an inclined document holder, Life and Pheasant (1984), reported a tendency to lean the trunk backwards and to flex the shoulders forward.

4. Keyboards with forearm supports also help facilitate a backwards leaning trunk posture. Compared to small supports, large forearm supports have been found to result in a greater trunk inclination and elevation of the arms along with greater pressure being exerted on the supports (Nakaseko et al, 1985).

Proper forearm support is essential for maintaining an elevated arm posture. Keeping the upper arms elevated forwards without proper forearm support will produce a high torque about the shoulder joints. Resulting musculo skeletal stress could then only be reduced by leaning the trunk forwards from the backrest, thereby reducing the postural torque about the shoulder joints (Nakaseko et al, 1985); Zacharkow, 1988).

Proper arm support can also reduce the loading of the lumbar spine and the lumbar interveterbral disc pressure as the weight of the arms will be taken by the arm supports (Occhipinti et al, 1985; Andersson and Ortengren, 1974b). In addition, with a large forearm support one would be able to exert greater pressure against the support, which will help extend the upper trunk. This will help to facilitate a backward leaning trunk posture with greater support being obtained from the backrest of the chair (Nakaseko et al, 1985). The resulting posture will further help reduce the lumbar intervertebral disc pressure (Zacharkow, 1988).

SEATED WORKING POSTURE

A forwards leaning posture at an office workstation with an unsupported lower spine has been corelated with an increased incidence of neck and back pain (Maida et al, 1980a; Ong et al, 1981; Sauter, et al 1983). With ergonomic improvements at a workstation kyphotic forward bending postures have been found to be almost totally eliminated as the VDT operators were observed to spend most of the sitting time with the trunk supported by the backrest of the chair (Cantoni et al, 1984).

Proper back support, arm support and foot support are critical for optimal body stabilisation (Darcus & Weddell, 1947; Branton, 1969; Kroemer, 1982; Nakaseko et al, 1985). An increase in operator performance has been observed in several studies after various ergonomic improvements contributing to operator stability, such as non-flexible backrest with lumbar supports, footrests and the use of inclined arm supports (Rohmert and Luczak, 1978; Ong, 1984; Secrest and Dainoff, 1984).

To allow a backwards leaning posture of the trunk with proper spinal support, an operator's chair should not only supply proper pelvic-sacral support, but should also have a backrest high enough to provide thoracic support. The back rest should also have an adjustable inclination, that can be fixed at any angle preferred by the operator (Grandjean, 1984b; Sauter et al, 1984).

The following factors will all help the operator obtain proper back support and trunk stabilisation from a high inclined backrest -

1. An inclined seat surface with non-slippery upholstery cover.

2. Large forearm support (Nakaseko et al, 1984).

3. Adjustable inclined document holder (Ferguson and Duncan, 1974; Life and Pheasant, 1984);

4. A detachable keyboard (Sauter et al, 1983);

5. Proper foot support with either the feet placed on the floor or else on a footrest (Coe, 1984).

Footrests maybe required particularly by smaller stature VDT operators, either when using chairs with an in adequate seat height adjustment, or when at a VDT table that is too high or is non adjustable.

Important considerations in footrest design for proper body stabilisation and comfort are the following (based on (Benz et al, 1983, Cakir et al, 1980; Bell Telephone Laboratories, 1983; Schmidtke, 1984; Ruhmann, 1984; Marriott and Stuchly, 1986) -

i. non-slip upper and lower surfaces are necessary to properly stabilise the feet on the footrest, and the footrest on the floor;

ii. the footrest should be adjustable in height and inclination. Fixed footrests also need to be adjustable in the horizontal distance from the operator;

iii. a fixed footrest should be securely attached to the table or floor. With a moveable footrest, a non slip floor covering is critical;

iv. a footrest should have a large enough surface to allow changes in foot position. This is critical, as the main disadvantage of a footrest is the restriction of leg movement compared to having the feet firmly and comfortably on the floor with degrees of freedom of movement for performance and comfort by the operator (Kotelmann, 1899; Shaw, 1902; Kerr, 1928; Sauter et al, 1984).

1.1.2.7 Seated Working Posture and Design Implications of Work Stations

"In regard to the sitting posture, I believe the time will come when we will have to comform our chairs to the individual rather than the individual to the chair" (Meisenbach, 1915).

The proper desk inclination and desk-chair relationship are critical to ensure erect posture of the head, neck, and trunk (Bendix and Hagberg, 1984; Weber et al, 1986). Neck muscle tension forces and cervical compression forces will be reduced with an inclined desk (Less and Eickelberg, 1976).

Back rest designs that push the shoulders forward will increase the upper thoracic kyphosis and result in a forward position of the head (Hawley, 1937).

Proper arm support is critical to promote extension of the upper thoracic spine, along with the more erect head and neck posture. In addition, proper arm support can significantly reduce the trapezius muscle load (Mahlamaki and Granstrom et al, 1985; Kvarnstrom, 1983; Avon and Schmitt, 1975). This is critical for supporting elevated arms in various work situations, thereby reducing the static load on the shoulder and neck muscles (Westgaard and Aaras, 1984).

There are several ways of achieving proper arms support, such as -

i. on the desk, if there is a proper chair - desk relationship;

ii. upon the forearm support of a keyboard;

iii. from armrests attached the work surface (Rohmert and Luczak, 1978);

iv. from armrests on the chair;

v. with hands in the lap.

(after Zacharkow, 1988).

It is critical that armrests are adjustable to provide proper support for the specific task requirements. Lack of adjustability is generally a fault in the current armrest designs available for chairs. Armrest adjustments are needed in height, angle of inclination, fore-aft adjustment, and adjustability and distance between the armrests (Aaras, 1983).

Thomas Goldthwait, 1922, considered three factors to be critical in maintaining an erect trunk posture when sitting:

1. Maintain a normal axial relationship of the thorax and the pelvis;

2. The ribs and chest must be raised to the normal position;

3. The head must be held in the normal position.

Critical chair design feature needed to fulfil the first two factors is a proper back rest support over the T9 through to L1 region of the spine. Proper back support will promote spinal extension along with stabilisation of the thorax (Vulcan et al, 1970).

The inferior angle of the scapula is located opposite the 8th thoracic vertebra (Lovett, 1916; Basmajian, 1977). This would indicate that critical back support should be located just below the shoulder blade.

Rathbone, 1934, felt that proper chair design with back support to the spinal region could also improve standing posture - "While the chair is holding the trunk in extended position, the neuromuscular system is being patterned in a desirable posture which can carry over into standing and into movements".

However, without proper extension of the lower thoracic spine, along with activation of the lower abdominals, there will be a decreased resting intra-abdominal pressure and a lowering abdominal viscera. The resulting relaxed and protruding lower abdomen will then cause the pelvis to gradually migrate forwards on the seat. Proper axial relationship of the thorax and pelvis will be lost, along with the loss of pelvic and trunk stabilisation. The sitter will then spontaneously search for other less healthy means of postural stabilisation (Mosher, 1899).

It is critical for the backrest to provide proper pelvic stabilisation (Cohn, 1886; Branton, 1969; Schoberth, 1969). This will reduce or prevent backwards rotation of the pelvis, along with having a beneficial effect on the lumbar spinal posture. The shape of the lumbar spine when sitting depends directly on the position of sacrum and pelvis, support must be given to the upper sacrum and posterior iliac crests (Cohn, 1886; Schoberth, 1969, Oxford, 1973; Wilder et al, 1986).

The commonly placed lumbar support, designed to fit the lumbar concavity, will loose contact with the spine as the individual leans forwards away from the backrest. Proper pelvic-sacral support, can still provide pelvic stabilisation in a forward leaning posture (Cotton, 1904, 1905; Schoberth, 1969).

According to Cotton, 1904, in leaning forwards there is "a slight rocking of the pelvis, in attendancy of the pelvis to slide back (on the yeilding flesh of the buttocks) in such a way that the back is still in contact with the support, and it may be definitely steadied by this support if it is properly curved. This point seems to have been overlooked. Of course, unless there is a free space beneath the lower edge of the back-rest no such motion occurs - an important reason in favour of leaving such a space free".

Additional pelvic stabilisation will be provided by the following chair features (Hoppenfeld, 1976):

i. an inclined seat (Akerblom, 1948; Murrell, 1965; Ayoub, 1972);

ii. a slight concavity to the sitting surface for the buttocks (Kroemer and Robinette, 1968);

iii. avoidance of seat cushioning that is to soft (Kohara, 1965; Branton, 1966, 1970);

iv. avoidance of slippery, low surface friction seat covers, (Branton, 1969; Schaedel, 1977);

v. the ability to have both feet firmly supported on the floor (McConnel, 1933).

Proper foot support when sitting is important for the following reasons:-

i. pelvic stability will be enhanced when the feet are firmly supported on the floor (McConnel, 1933);

ii. it will facilitate the use of the backrest (Swearingen et al, 1962; Darcus and Weddell, 1947);

iii. it is critical to avoid posterior thigh compression and the obstruction of venous blood flow from the lower legs (Pottier et al, 1967, 1969; Morimoto, 1973);

iv. it will facilitate leg position changes, thereby allowing a change in joint angles and muscle tension at the hips, knees, and ankles along with reducing venous blood stagnation in the lower legs.

A change in one's leg position can also temporarily shift pressure for the ischial tuberosities (after Zacharkow, 1988).

According to Shipley (1980), "Too high a seat leaves the feet dangling and unsupported, inducing the sitter to sit forwards in order to plant his/her feet on the floor and so avoiding excessive pressure of the underside of the thighs, but at the expense of back support. Similar problems can arise from seats being too deep".

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In regards to school children, Cohn (1886), observed that when the feet are dangling "... the child soon grows tired. He/she tries to reach the floor with the tips of his toes at least; and in doing so he/she bends the thigh downward, slides forward on the edge of the floor and presses his/her chest on the edge of the table. A necessary result is a further collapse of attitude."

Sitting of the front portion of the high seat will be both an unstable and a fatiguing posture (Kroemer and Robinette, 1968). At the other extreme, the acute angle between the thighs and trunk resulting from a very low seat height will increase the flexion stress to the lumbar and thoracic spine. The approximation of the thorax to the pelvis will also increase the pressure on the abdominal viscera (Aveling, 1879).

Leg position changes will be facilitated by -

i. the proper seat height (Akerblom, 1954; Andersson and Ortengren, 1974);

ii. a proper seat depth. Freedom of leg movement will be lost as the seat depth is increased (Ridder, 1959). However, a very short seat depth may feel unstable and also result in a lack of surface for free movement of the legs (Bennett, 1928).

iii. a rounded front edge to the seat, which will prevent the front edge from cutting into the distal posterior thighs with leg position changes (Keegan, 1953; Asatekin, 1975; Coe, 1979).

Although footrests will be necessary for some individuals in order to obtain proper foot support they do have some disadvantages -

i. they limit the free movement of the individual's legs. Holding the lower legs continuously in the same position can be very fatiguing (Kotelmann, 1899; Shaw, 1902; Kerr, 1928);

ii. the footrest should have an inclination similar to the seat inclination. Otherwise, a very acute angle of the knees may result. (Kotelmann, 1899).

Intermittent leg exercises is important during prolonged sitting to reduce the swelling and discomfort of the lower legs (Winkel, 1981; Winkel and Jorgensen, 1986). Prolonged passive sitting is also considered a causative factor in venous thrombosis of the lower extremity (Homans, 1954; Makris et al, 1986).

The movement of the seated worker at his desk/her desk made possible on chairs with castors can help produce foot swelling (Winkel and Jorgensen, 1986). However, castors can also require increase static muscle work from the legs and lower back in order to keep the chair in position, especially on hard floors (Lundervold, 1951a; Damodaran et al, 1980; Bell Laboratories, 1983).

Therefore, the type of castor and the type of floor covering are both important factors.

SEATED WORKING POSTURE

1. INTRODUCTION

1.2 REVIEW OF STANDARDS AND GUIDELINES

Standards, codes of practice and guidelines on the design of furniture - principally tables and chairs, and the appropriate setting or "correct" posture required of the users, have been issued by governments, trade unions and manufacturers of equipment and furniture.

The first international standard was issued by the International Organisation for Standardisation (I.O.S.), as document TL 136/SC7 in 1978. The Commite European de Normalisation, Paris, France followed with a publication in 1980. The former purports to be a "postural standard" whereas the latter a "furniture standard", but in practice they are both used internationally for dual purposes by health professionals and designers alike. Very similar documents were produced by the Danske Arkitekters, Copenhagen, Denmark, 1981, and by the Department of Defence, United States of America as a military standard for the North American Services Group, and known as MIL-STND-1472C, revised 2 May, 1981.

Occupational health and safety standards incorporated the postural data of the International Organisation for Standardisation (1978) document from 1979, when the Swedish Board of Occupational Safety and Health published a document principally about the design of visual display terminals and keyboards. German DIN standards followed in 1980/81 and in the U.K. guidelines were released in 1983 (Helander and Rupp 1984). An International Organisation for Standardisation committee, No. 159, has been meeting since 1983 and a document is to be released by them for comment. A plethora of publications about this subject followed embodying the postural geometry of the I.O.S. (1978) standard.

SEATED WORKING POSTURE

In Australia, the Working Environment Branch of the then Department of Science and Technology, published simple guidelines in a booklet entitled "V.D.U's at Work", first published in 1981. The document incorporates the postural geometry for seated work prescribed in the I.O.S (1978) standard.

In 1983 the Australian Council of Trade Unions - Victorian Trades Hall Council (ACTU - VTHC), circulated guidelines on the use of screen-based equipment which included recommendations for the "correct" seated working posture as described by the I.O.S. (1978) standard. The Standards Association of Australia set up Technical Committee SF/38 in 1983 at the request of the Australian Council of Trade Unions (ACTU). However, by the time the committee met the ACTU had withdrawn its support in favour of the then newly formed National Occupational Health and Safety Commission, who since has not issued any definitive advice on working posture or on the use of screen based equipment. In the meantime, the Standards Association of Australia has proceeded without ACTU support and at the time of writing has a standard published May, 1990 titled "Screen-based workstations" and is presented in two parts representing equipment and working environment matters. The seated working posture depicted and described in the published part 2 : Workstation furniture, is from the I.O.S. (1978) model. (Whiteman, D., Research Officer, Standards Association of Australia, personal communication, May, 1990).

As with other aspects of this area of study, standards and guidelines from around the world vary in their use and definition of the terminology. What is common between all such documents is the seated postural geometry of the model used and known as the "German Square", which depicts upright trunk, 90 degree upper and lower limb geometry with head erect and the subject viewing straight ahead.

The documents though, differ in lineal dimensions applied to "correct" or "ideal" working height(s) for the eyes above the floor, shoulder acromion to the home row of keys (or pen grip position), and viewing distance to copy. None of the documents provides any data as to the origins of the information about "correct" or "ideal" postural geometry for seated work. No explanation is given of the science or otherwise, involved in the derivation of the postural angles, lineal dimensions, the relationship of seated work to work station furniture and equipment, or the instruction embodied in the "German Square" model that the posture is basically a static one.

SEATED WORKING POSTURE

1. INTRODUCTION

1.3 DISCUSSION OF STANDARDS AND GUIDELINES

Standards, guidelines, regulations, codes of practice and recommendations collectively referred to as "standards" in this paper, are issued by a variety of interested parties. They are the user groups, trade unions, industry officials, scientists and government bodies. The groups have different needs, aims and accountabilities.

Typically, the designers and draughters of standards represent widely separate groups whose interests are not always congruent. The result has been that the rationale forming the standard has not always been based on fact but rather on consensus. This may be due to the optimum not always being known; it may be changing or it may be difficult to achieve either technologically or economically. Thus the motivation and needs of the designers of standards and of those who may endorse them, needs to be examined and made clear. Political expediency on behalf of the sponsor, may interfere with the policy, the design, and the application of standards.

Once written, standards may effectively become precedents when they are referred to in the common law. Standards tend to be regarded as maxims when the intention of the draughter is a minimum; unless written with care and consideration they may not be compatible with technological change and may be outdated before securing a useful publication life. The process of upgrading or rewriting standards is lengthy and is fraught with the same dangers of mixed motivations encountered in the production of an original document.

Unfortunately, standards have a habit of repeating themselves insidiously as one group after another adopts that which is first produced and replicates it. (Blucett, 1984).

Assistance is needed by the general public who need fast, expert advice, and so standards as a form of communication have been developed. The standards referred to and reviewed within this paper are all in use in various parts of the world.

The earliest standard reviewed was published in 1979 by I.O.S. and it has become the international standard for seated working posture and for the design of furniture for seated work. The so-called international standards published by the I.O.S. (1979) and the C.E.N (1980), both give very explicit and identical geometric guidelines for seated work but differ in numerical values, as do the standards that have since followed this familiar format.

That logical standards be produced is vital so that clear parameters or ranges for the elements can be established and relied upon. It is clear that they must be written to be flexible enough to cope with a range of technologies. Standards must not inhibit innovation and must be based on the clearest evidence available. The needs of those using standards varies greatly - from the designers and manufacturers of equipment, to the users and the procurers of workstation equipment; this diversity must be accommodated by the draughters of standards.

Standards can generate important economical, sociological and political consequences, particularly if they acquire the status of mandatory requirements or become statutes of the law.

Much of the responsibility for the production of concise and accurate standards is firmly with the scientific community.

1. INTRODUCTION

1.4 REASONS FOR RESEARCH

Zacharchow in "Posture: Sitting, Standing, Chair Design and Exercise" (1988) summarised the characteristics of the three basic unsupported sitting postures (after Andersson et al, 1975), and concluded that "there will be many variations in the posture of the lumbar spine in the upright sitting position". According to Akerblom (1948), "some of the curves are very different from those obtained in the relaxed position, while on the other hand there are a few cases in which the curves are hardly to be distinguished from those obtained in the standing position. However, they usually show an intermediate position between standing and maximal ventriflexion." Hooton (1945) in his survey of body measurements for seat design concludes that the lumbar lordosis "tends to be flattened practically to the vanishing point in most subjects when they sit erect".

A common misconception is to consider sitting in a chair as a static activity, as opposed to a dynamic activity (Zacharkow, 1988). According to Brandon (1966), the sitting body is "not merely an inert bag of bones, dumped for a time in a seat, but a live organism in a dynamic state of continuous activity".

That research and experimentation is required to confirm and consolidate such views, is vital.

SEATED WORKING POSTURE

The groups critically in need of information on seated working posture and the design of furniture and ancillary equipment that effect posture are the purchasers, the users, trainers, trade unions and the manufacturers. Well-informed purchasers, users, trainers and trade unions will demand furniture and ancillary equipment that effect posture, of a particular standard and will agitate for manufacturers to produce such equipment. The task of ensuring that the groups are appropriately informed is with the scientific community, in government, academic institutions, and within the health training industry. The need has been met in part but the fundamental fault of the many standards and guidelines about furniture design - anthropometry - seated working posture, is that they are not based on good science.

The importance of laboratory - based research in establishing postural principles for seated work is paramount, but research about seated working posture in the work place must be conducted to ensure appropriateness. Recent research to date has been almost exclusively by orthopaedic surgeons and has been largely been based in laboratories using techniques that do not usually reflect tasks of the seated worker.

Little is known about the relationship of the six main angular elements of seated postural geometry - trunk inclination, head inclination, arm flexion, elbow angle, arm abduction and left ulnar abduction, to each other in the terms of expectation and intrinsic safety, or about the link between seated operator performance and comfort. The effects of the three main lineal dimensions of seated working posture - seated eye height above the floor, acromion distance of shoulder to the home row of keys (or pen grip position), and eye to copy distance to each other and to the angular elements, are little studied. The postural effects of the lineal dimensions and the link between operator comfort and performance have also not been studied. Opthalmological studies reviewing eye tiredness and V.D.U workers (Richter, 1981) have sought to prove or otherwise the evidence of eyestrain, but not to explain the operator preference for visual distance to copy.

SEATED WORKING POSTURE

Research in the late nineteenth and early twentieth centuries was negated by inappropriate methods and a lack of coordination between the researchers interested in work station furniture design and those interested in seated working posture. The small amount of specialised research conducted post world war two has been negated by singular aims of individuals, difficulties of inappropriate methods, the use of inappropriate statistics (Mandal, 1984), and lack of controls. The gaps in the scientific knowledge about seated working posture are large.

Reviewing the body of scientific knowledge, it is considered appropriate to repeat some of the laboratory testing (Grandjean et al, 1983), in a work place setting.

This is a rationale for a research proposal as follows:-

- assess the preferences of data processors with regard to their seated body posture;

- compare the preferential seated postural data against that prescribed by the "German Square" seated postural training model;

- investigate if possible, the realtionship(s) between the six main angular elements of postural geometry together with the three main lineal dimensions of seated working posture.

1. INTRODUCTION

1.5 HYPOTHESIS

The hypothesis is that a population of alpha and numeric data processors who have received training in the "German Square" model of seated working posture, do not comply with the angular and lineal dimensions established by the training model.

In order to test this hypothesis, data processor operators within Australia Post were asked to participate in the workplace based measurements of preferred seated working posture.

2. METHODOLOGY

2.0.1 Generally

The experimental measurements were undertaken in Australia Post Mail Centres at Brisbane (QLD), Rushcutters Bay, Clyde (NSW), Clayton South (Vic) and Adelaide (SA), and in the offices at 71 Rathdowne Street, Carlton South and 191 Queen Street, Melbourne, (Vic).

2.0.2 The Systems of Work - Description

The hypothesis was tested using two experimental groups of data processor operators.

Letter indexing desk operators within the target mail centres were chosen as "Experimental Group A" personnel. The desk operators are employed as "Mail Officers" and are members of the Australian Postal and Telecommunications Union. Letter indexing desk operators process standard letters in an automated desk system of work which presents each letter in the cone of vision of the seated operator for alpha-numeric keycoding of the destination address. The cone of vision for letter indexing desk operators is primarily in the plane of the letter presentation band on the machine.

Steno-Secretary and key-punch operators within the Headquarters and State Administrative offices were chosen as "Experimental Group B" personnel. The operators are employed in administrative categories and are members of the Public Service Union. Steno-Secretaries process words and a minimum of numbers in a computerised desk system of work which displays the work in progress on a cathode ray tube (CRT) screen.

SEATED WORKING POSTURE

The cone of vision for the Steno-Secretary when working with a computer, is primarily within the plane of the screen. Key-Punch operators process numbers and a minimum of words in a computerised desk system of work where the hard copy data is moved by the left hand, whilst the right hand performs the keying tasks. The cone of vision for the key-punch operator is primarily in the hand-work plane.

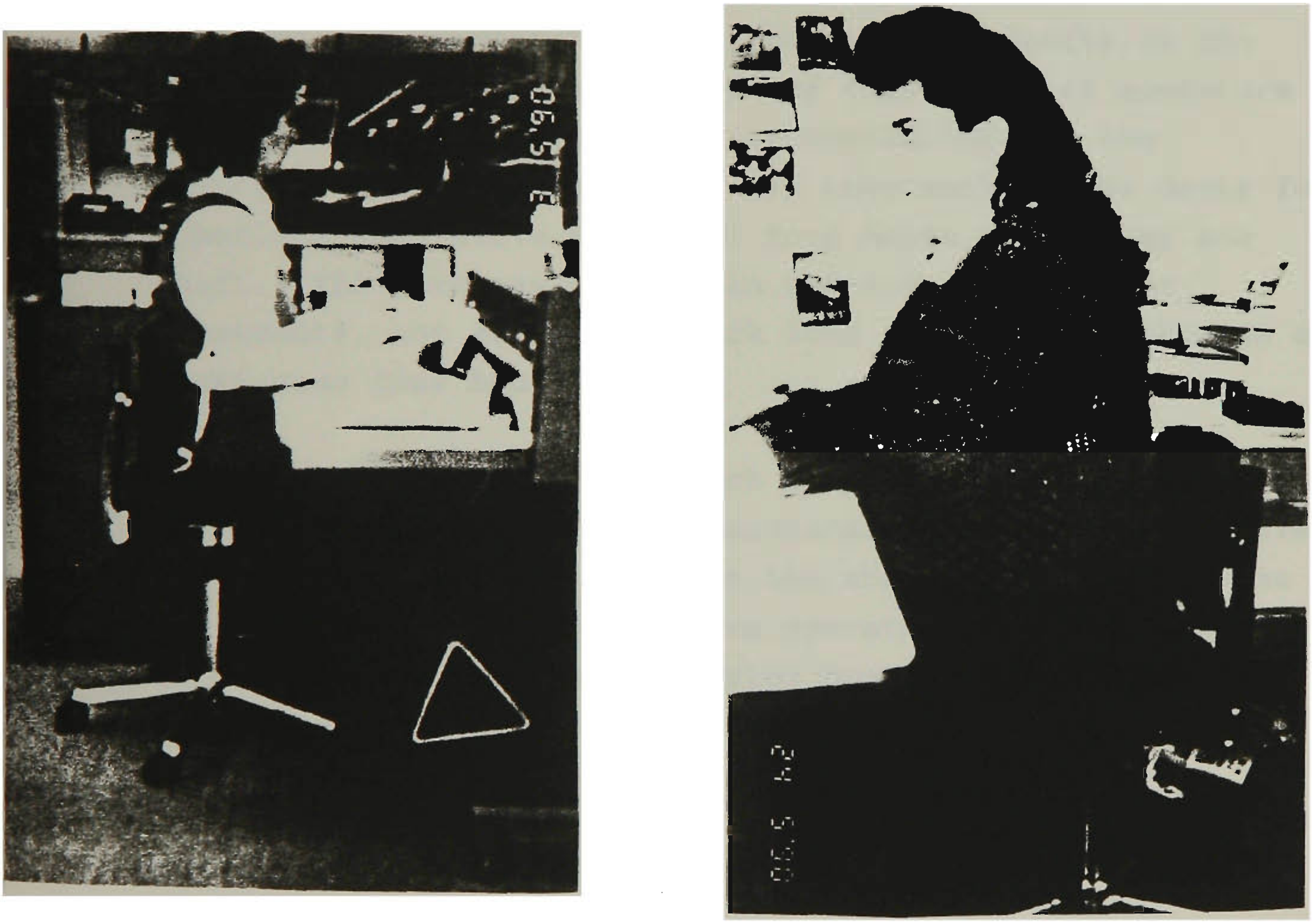

FIGURE 21. Typical Experimental Subjects Performing Data Processing Work at Fully Adjustable Furniture

- A. Letter Indexing Operator at Clayton South Mail Centre, Australia Post, Victoria.

- B. Word Processing Operator at Headquarters, 71 Rathdowne Street, Australia Post, Carlton South, Victoria.

2.0.3 The Population of Operators

Histogram summaries within each group for body stature, body mass, age, sex and natinality are "Appendix H" to this paper.

Letter indexing desk operators comprise males and females of relatively evenly distributed numbers and represent an expected demographic distribution found currently in the Australian work force. The Letter indexing desk operators are rostered to work shifts distributed through the twenty-four hour daily cycle, and they work at the desks for a maximum cumulative period of four hours within any one shift. The work may be done in one hour or two hour increments, but subject to work load can be undertaken in a continuous four hour period.

Steno-Secretaries and key-punch operators comprise males and females of relatively disproportionate numbers, with female occupants of the jobs being in the absolute majority. The distribution of origin of these operators is considered to be representative of the expected demographic spread currently being experienced in the Australian workforce (O.C.E.C., 1987).

The demography of the population studied is described as follows:-

Experimental Group A		Males	Females
Australian	27	19	8
Asian	16	10	6
European	2	-	2
Other	2	1	1
TOTALS	47	30	17

Experimental Group B		Males	Females
Australian	31	2	29
Asian	3	-	3
European	8	-	8
Other	5	1	4
TOTALS	47	3	44

TABLE 1. Summary Data for Experimental Groups A & B Showing Nationality Groups.

Steno-Secretaries and key-punch operators work "standard" office hours of approximately 8.45am to 4.45pm, work consistently at the one workstation and usually at a dedicated task of work without job rotation.

The population studied is considered to be a normally distributed one being closely allied to that described in "Humanscale" 1/2/3 (1974) and 4/5/6 (1981) (Diffrient et al), with the data for Experimental Groups A and B being as follows:

Experimental Group A

- minimum age 21 years
- maximum age 51 years
- mean age 31 years (stand dev. 7.2)
- minimum height 1555mm
- maximum height 1938mm

Experimental Group B

- minimum age 20 years
- maximum age 61 years
- mean age 29 years (stand dev. 8.1)
- minimum height 1441mm
- maximum height 1811mm

- mean height 1706mm (stand dev. 92.6)	- mean height 1637mm (stand dev. 82.8)
- minimum body mass 49kg	- minimum body mass 45kg
- maximum body mass 100kg	- maximum body mass 105kg
- mean body mass 69.2kg (stand dev. 11.8)	- mean body mass 62.8kg (stand dev. 12.4)

TABLE 2. Summary Data for Experimental Groups A & B Showing Ages, Heights and Body Masses.

The sample size for each group was forty-seven operators; fifty-four candidates were measured in Experimental Group A but the data for seven subjects were discarded due to errors made in taking some measurements.

Measurements were undertaken from 11th May, 1989 to 7th September, 1989.

2.0.4 Experimental Measurement Protocol

Individual operators in both groups were randomly selected, approached and asked if they would participate in the experimental measurement task, and upon a positive response each individual had explained to him/her the reasons the study was being undertaken but no work was attempted with those reluctant to participate.

Measurements of a total of nine categories of posture - three lineal and six geometric, were undertaken after two minutes of elapsed time from introduction, and then after a total eight minutes of elapsed time. The time intervals were based on the requirement for each operator to settle into as close as possible to a preferred work routine and adopt a preferred seated working posture, and to continue until a natural break in the work would normally occur (after Grandjean et al, 1982).

2.0.5 Experimental Measurement Technique

Pretest procedures for validating limits of 'no movement' consisted of taking a total of nine measurements - three lineal and six geometric, of seated working posture and retesting immediately. The measurements are described in following pages Nos. 76 & 77. The results of each test and retest were compared for ten different operators of letter indexing desks, and the range of repeated measurements for postural angles was found to be ± 2 degrees and ± 5mm for lineal postural dimensions. Grandjean et al (1983, 1984) reported similar measurement accuracy, when examining preferred workstation settings for V.D.T. operators.

Angles and distances were measured during subjects normal seated working activities of data processing. The distances were measured using a retractable Stanley "Powerlock" steel tape with a standard stadiometer to establish vertical and horizontal planes for the intersecting points. The distances measured were the eye height from the centre line of the superior oribtal fissure of the eye socket, above the floor, the shoulder acromion process height above the home row of keys on the board (or the pen grip position for the dominant hand) in the vertical plane, and the visual distance from the centre line of the superior orbital fissure of the eye socket, to the screen or hard copy centreline. The viewing angle (eye to screen centreline to horizontal plane), if required, could therefore be established from eye height, visual distance, and screen centre height.

Six postural angles were measured with an oil-damped, level bubble goniometer which was hand held - a procedure that provides a general measure of postural angles. Trunk inclination was measured as the angle formed between the lateral condyle of the knee, the greater trochanter of the hip and the shoulder acromion process.

SEATED WORKING POSTURE

As seat tilt facility was unavailable to experimental group subjects, trunk inclination measurements do not discriminate the angle of the seated thighs to the horizontal, viz, where the thighs were not parallel to the floor the results in degrees of inclination represent the angle of opening between the trunk and the thighs only. Head inclination was measured as the angle formed between the C7/T1 spinal joint, the tragion of the ear, and a vertical plane.

Arm flexion was measured as the angle formed between the shoulder acromion process, the lateral epicondyle of the elbow and a horizontal plane. Arm abduction was measured as the angle formed between the shoulder acromion process, the medial epicondyle of the elbow and a vertical plane. Elbow angle was measured as that formed between the shoulder acromion process, the lateral epicondyle of the elbow and the ulnar styloid process at the wrist joint. Left ulnar abduction was measured as the angle formed along the anterior plane of the thumb to the meeting point of the radial styloid process, and to the distal digit of the middle finger forming a line along the capitate and metacarpal bones (hand in the pronated position).

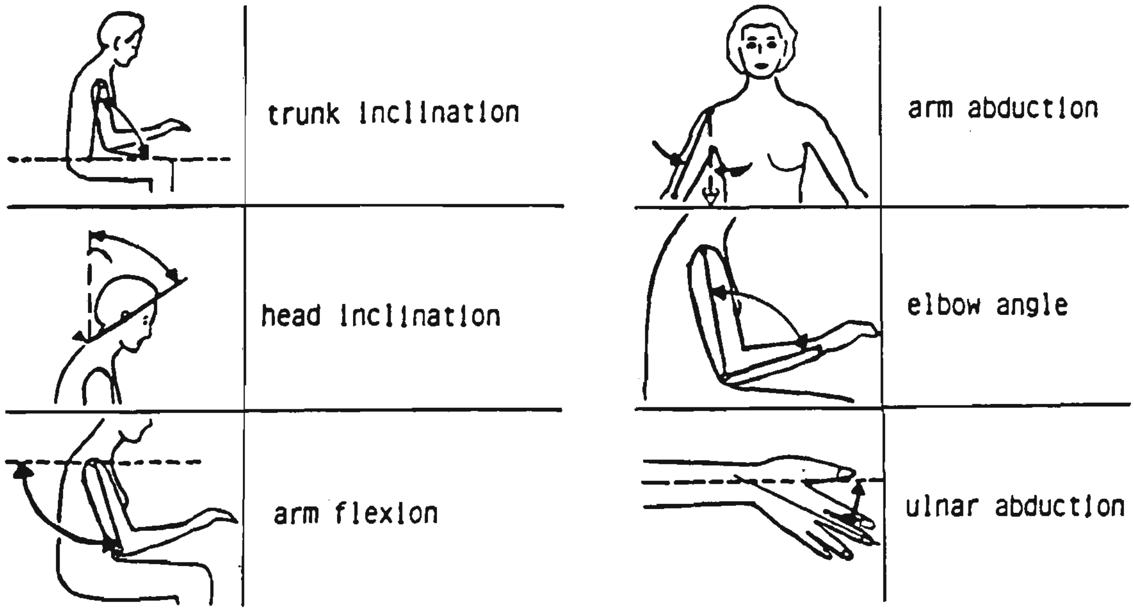

FIGURE 22. The Measured Postural Angles.
Adapted from "V.D.T Workstation Design", Grandjean et al, 1983.

A proforma was used to record all data in the field, individual operators were shown the completed proforma and results were explained upon request.

The workplace generated proformas are "Appendix I" to this paper.

2.0.6 Statistical Method

To determine the inter-relationships between the preferrential seated working posture adopted by data processors, and the seated working postural model known as the 'German Square' administered by occupational health and safety trainers, statistical measurements to establish the mean, the standard deviation, the variance and a distribution for a population sampled and found to be normal, were undertaken for all classifications of the data.

Anthropometric and demographic data - in the terms of body stature, body mass, sex, age and nationality, were gathered and analysed to determine the variation across the workplace. Means, standard deviations, variance, and arithmetic distributions of the data were measured.

Because the population of data processors randomly sampled in the field tests equated to a normally distributed population, "Student's" t distribution (an exact sampling theory since the results obtained hold for large as well as small samples, according to Neter, Wasserman & Whitmore in "Fundamental Statistics for Business and Economics", Ch. 11, p. 188, 1973) was chosen to analyse the "within" group data to compare the preferential working postures with that prescribed by the model, at 2 minutes and 8 minutes respectively.

The second set of significance tests were applied "within" group to establish whether or not there was change between the seated working postures adopted at the 2 and 8 minutes positions, compared against the static seated working posture prescribed by the model. The third set of significance tests were applied "between" groups to test whether or not experimental Group A data is different to experimental Group B data.

Complete statistical analyses of t-distribution within and between groups measurements are "Appendix G" to this paper.

3. RESULTS & DISCUSSION

Complete tabular results for the nine categories of postural measurements are "Appendix A" to this paper. The results include statistical analysis within groups for sex and for nationalities. Complete statistical analysis of t-distribution within and between groups measurements are "Appendix G" to this paper. Summaries of these results are presented within this section of the paper and are referenced as sub-sections .1 to .10. Discussions follow each as a sub-set.

The International Organisation for Standardisation (1978) seated postural model is incomplete in lineal dimensions and thereby differs from other models and standards that show identical seated body geometry. Because of a lack of standardisation for lineal units, "average" eye to floor height, shoulder acromion process to keyboard home row height and eye to copy distance data for seated adults has been adopted from "Humanscale" (1974), and this data has been used as the model.

3.1 Eye to Floor Distance

EXPERIMENTAL GROUP - A EXPERIMENTAL GROUP - B

(OVERALL RESULTS)

SAMPLE SIZE 47

EYE/FLOOR DISTANCE (mm)

	Group A AFTER 2 MIN	Group A AFTER 8 MIN	Group A MOVEMENT	Group B AFTER 2 MIN	Group B AFTER 8 MIN	Group B MOVEMENT
Minimum	1178	1180	0	1005	1010	0
Maximum	1300	1285	75	1680	1640	100
Average	1240	1241	10	1213	1219	26
Stnd Dev.	28.5	22.8	13.2	159.5	165.8	27

TABLE 3. Summary Data for Experimental Groups A & B showing Eye to Floor Distance, and Movement at 2 and 8 minutes.

Data in Table 3 and "Appendix A", show B that eighty-three subjects (83/94) in the experimental groups were not sitting at eye height 1187mm above the floor as prescribed by "Humanscale" (1974), after 2 minutes and eight minutes of work respectively. The within group analysis also showed the averages of the 2 minutes and 8 minutes preferred working positions, and by comparison with the model established that the majority of subjects in both groups moved over an eye to floor distance during the course of eight minutes of the data processing work. In group A, twenty-four (24/47) subjects moved more than 5mm over the period; in group B, thirty-nine (39/47) subjects moved more than 5mm over the period, indicating that the majority of the subjects moved.

The third t-distribution test was applied to between groups A and B data, and it established that there are no statistically significant differences between group A and B subjects sitting at work after 2 and 8 minutes respectively. That is, statistically the data for both groups can be considered as for one group.

3.1.1 Discussion of Eye to Floor Distance Results

The data indicates that some female subjects (n = 4) chose to sit at an eye height above the floor greater than that predicted for respective trunk stature and lower limb length, and individuals explained this preference for seated working height in terms of the difficulty to adjust the work surface of the table. Because footresting facilities were available and seat adjustability was reported to be relatively easy by such female subjects, these means of obtaining balanced seated posture (subjective observation) were utilised.

Grandjean et al (1983) when reporting operator preferred settings of VDT workstations, for eye to floor height category from 65 observations for 65 subjects recorded a mean preference of 1150mm, a standard deviation of 54mm and a minimum-maximum range of 1070mm to 1270mm. These results are different to those recorded for experimental groups A and B, but show similarity in that movement occurred and that the means of the subject groups differ from that prescribed by the model. The differences cannot be explained by the data.

Further research into what constitutes intrinsically safe operator comfort and performance parameters for eye to floor distance, is required.

The German DIN standard No. 4549 (1981) proposes a desk level of 720mm for a VDT workstation. According to Grandjean et al (1983) this proposal is based on anthropometric considerations of upright-sitting operators, and as a result has promoted lower than desirable seated eye heights above floor level for data processing operators.

The eye to floor distance impacts upon viewing position as a predeterminant of the viewing angle, and also upon other elements of seated working posture - especially head inclination. As both hard copy and screen based character readers were measured in groups A and B, the work of Gould and Grischowsky (1984, 1986) who made attempts to determine which factors are critical to speed and accuracy when reading text on a VDT, are of interest. In 1984 Gould and Grischowsky compared the same tasks being performed with hard copy and with a VDT and found that hard copy text reading was performed about 20% to 30% faster than VDT reading.

In 1986, Gould and Grischowsky tested the effect of visual angle as a possible contributor to a suspected decline in speed and accuracy, using similar tasks. They found for visual angle within the range 16 to 36 degrees, speed and accuracy were unaffected. For experimental group A and B subjects, the viewing angle (eye to reading data centreline to horizontal plane) was determined from eye to floor height, visual distance to the reading data, head inclination, and height above the floor to the hard copy on screen centre point.

The viewing angles for experimental groups A and B were calculated as described on page 76 and correspond to those prescribed for speed and accuracy by Gould and Grischowsky (1986). The minimum viewing angle recorded was 5 degrees, the maximum 43 degrees and the mean 27 degrees. By observation and operator feedback during the course of the experimental measuring it can be concluded that the viewing angles adopted did not slow down reading speed to hard copy or to a CRT screen. Gould and Grischowsky (1984, 1986) also concluded that viewing angle does not slow down the reading speed when people read from a VDT.

3.2 Shoulder Acromion to Keyboard Distance

EXPERIMENTAL GROUP - A EXPERIMENTAL GROUP - B

(OVERALL RESULTS)

SAMPLE SIZE 47

ACROMION/KEYBOARD DISTANCE (MM)

	AFTER 2 MIN	AFTER 8 MIN	MOVEMENT	AFTER 2 MIN	AFTER 8 MIN	MOVEMENT
Minimum	178	184	0	201	183	0
Maximum	323	321	32	330	332	50
Average	244	245	11	262	261	12
Stnd Dev.	34.7	32.3	8.4	29.2	28.8	9.9

TABLE 4. Summary Data for Experimental Groups A & B showing Shoulder Acromion Process Height Above Keyboard Home Row Distance, and Movement at 2 & 8 Minutes.

Data in Table 4 and "Appendix A" show that seventy-nine subjects (79/94) in the experimental groups were not sitting at shoulder acromion process position of 274mm above the home row of keys on the board (or pen grip position above the work surface) as prescribed in "Humanscale" (1974), after 2 minutes and 8 minutes of work respectively. The within group analysis also showed averages of the 2 minutes and 8 minutes preferred working positions, and by comparison with the model established that the majority of subjects in both groups moved over a shoulder acromion process distance to the home row of keys on the board during the course of eight minutes of continuous data processing work.

In group A, thirty-three (33/47) subjects moved more than 5mm over the period; in groups B, thirty-four (34/47) subjects moved more than 5mm over the period, indicating that the majority of the subjects moved. The third t-distribution test was applied to between groups A & B data, and it established that there are statistically significant differences between groups A and B subjects sitting at work after 2 and 8 minutes respectively. That is, statistically the data for each group cannot be considered the same.

3.2.1 Discussion of Shoulder Acromion to Keyboard Distance Results

Observation indicates that some female subjects (N = 3) chose to alter the shoulder acromion process height above the keyboard by adjustment of the chair seat height and the chair backrest column angle, rather than by adjusting the table worktop. Individuals explained this preference for altering head, arm and trunk posture as a response to the difficulty encountered by them in attempting to adjust the table workshop. Forces applied to table height adjustment mechanisms were recorded at greater than 200 Newtons - a rotational force indicated by Humanscale 7/8/9 (1978) to be excessive for female hands to apply. The changes in seated body posture for the subjects cited are confirmed by their individual trunk inclination preferences.

As tactile fatigue has been associated with keyboard profile and angle (Snyder 1979), it may provide an explanation of operator movement to shorten or extend the shoulder acromion process height above the home row of keys on the board. However, there is little in the literature concerning keying performance as a function of keyboard slope on keyboard profile (Knave et al 1983; Nelson, 1987).

Grandjean and co-workers, 1983, when examining preferred settings by operators of their VDT workstation furniture and equipment, found from 236 observations and 59 subjects a mean height of shoulder acromion process above home row of key to be 510mm, with a standard deviation of 50mm and a minimum-maximum range of 420mm to 620mm. The measured range of 200mm in the Grandjean et al (1983) study is beyond the ranges measured for experimental groups A and B. Considering that Humanscale 1/2/3 (1974) humeral link data for "average" stature adult males and females is a range 267mm to 282mm, it is difficult to explain Grandjean and co-workers results except to say that possibly their subjects presented an arm posture with elbow angle greater than 90^{o}. As the anthropometric data published by Grandjean et al (1983) states that of the 68 subjects a total of 9 were less than 1600mm and a total of 11 were greater than 1750mm in stature, it is assumed that the population was not normally distributed in that larger than expected trunk statures may dominate the sample.

By way of some contradiction by earlier work, Grandjean (1981) in publishing German rules of the "Verwaltungs-Berufsgenossenschaft", prescribed anthropometric considerations of upright-sitting operators to establish work station heights and seated working postures. These rules are repeated by the German DIN standard No 4549 (1981).

The differences in behaviour established by the t-distribution between groups A & B test, and the differences between this and the Grandjean and co-workers (1983) results cannot be explained by the data. Further research into what constitutes intrinsically safe operator comfort and performance parameters for shoulder acromion to keyboard home row distance, is required.

3.3 Eye to Copy Distance

EXPERIMENTAL GROUP - A EXPERIMENTAL GROUP - B

(OVERALL RESULTS)

SAMPLE SIZE 47

EYE TO COPY DISTANCE (MM)

	AFTER 2 MIN	AFTER 8 MIN	MOVEMENT	AFTER 2 MIN	AFTER 8 MIN	MOVEMENT
Minimum	550	552	0	478	488	0
Maximum	787	800	78	850	876	93
Average	670	671	17	700	707	26
Stnd Dev.	50.6	52.2	18.3	77.4	87.	21.3

TABLE 5. Summary Data for Experimental Groups A & B Showing Eye to Copy Distance, and Movement at 2 and 8 minutes.

Data in Table 5 and "Appendix A" show that all ninety-four subjects (94/94) in the experimental groups were not sitting at eye to copy distance of 460mm as prescribed by "Humanscale" (1974), after 2 minutes and 8 minutes of work respectively. The within group analysis also showed the averages of the 2 minutes and 8 minutes preferred working positions, and by comparison with the model established that the majority of subjects in both groups moved over an eye to copy distance during the course of eight minutes plus of continuous data processing work. In group A, thirty-one 31/47 subjects moved more than 5mm over the period; in group B, forty-two (42/47) subjects moved more than 5mm over the period, indicating that the majority of subjects moved. The third t-distribution test was applied to between groups A and B data, and it is established that there are statistically significant differences between groups A and B subjects sitting at work after 2 and 8 minutes respectively. That is, statistically the data for each group cannot be considered the same.

3.3.1 Discussion of Eye to Copy Distance Results

The extended maximum movements recorded for both groups experimental subjects (group A-78mm; group B-93mm) may be explained by preferred shoulder acromion process height above the home row of keys on the board, and this relationship to trunk inclination.

The data indicates that a random distribution of subjects (n = 8) preferred maximal movement of eye to copy from the 2 to the 8 minutes working positions. As only two of these subjects were older than thirty years of age (C17 - 42 years and C37-35 years), it is unlikely that age effect in lengthening preferred focal distance (presbyopia) is the reason for the change. The recorded movements show that some subjects were above and some below the model viewing distance during 8 minutes of seated data processing work. Individual operators interviewed post measurement taking, were unable to elucidate reasons for the change in preferred focal distance and were not primarily aware that they were changing focal distance during the course of the work.

Some operators in experimental groups A and B wore mono-focal or bi-focal spectacles, and were represented in the numbers of minimal and maximal movers. The reasons for changes in eye to copy distances reported for experimental groups A and B cannot be explained from the data generated within the study or from the scientific literature reviewed.

The main visual functions when performing data processing work are:

Accommodation - the ability to bring into sharp focus characters at different distances;

Convergence - the ability to co-ordinate the movement of both eyes so that the image transfers onto corresponding retinal areas;

Adaptation - the ability of the retina to adapt its sensitivity to varying luminances or colour stimuli (after Blewett, 1984; Nelson, 1987).

The visual comfort of data processors depends on workstation lighting and copy quality, the operators eyesight, working posture and age, as well as physical factors in the workplace (Blewett 1984; Cakir et al 1979; Howarth and Instance 1985; Nelson, 1987; Ostberg, 1982; Shahnavaz and Hedman, 1984). Objective measurements of visual fatigue have generally been based on the measurement of transient myopia - a condition frequently reported by VDT operators (Jaschinski-Kruza, 1984). Subjective measurements have relied on comfort - index based questionnaires and on interviews (Gould and Grischowsky 1984).

Kruk and Muter (1984) showed that viewing distance had no effect on reading speed, which was consistent with the findings of Morrison (1983).

Vassilieff and Dain (1986) asserted that if the workplace was designed with the needs of multi focal wearers in mind then multi focals should present little problem except in a few specific cases. Provision of height adjustment, swivel and tilt mechanisms, is relatively easy to achieve (Telecom Standard, 1985; Nelson, 1987).

Grandjean et al (1983), when examining preferred settings by operators of their VDT workstation furniture and equipment, found from 236 observations and 59 subjects a mean visual distance of 760mm, with a standard deviation of 75mm and a minimum-maximum range of 610mm to 930mm. These results are different to those recorded for experimental groups A and B, but show similarity in that movement occurred and that the means of the subject groups differ markedly from that prescribed by the model.

Further research into what constitutes intrinsically safe operator comfort and performance parameters for eye to copy distance, is required.

3.4 Trunk Inclination

EXPERIMENTAL GROUP - A   EXPERIMENTAL GROUP - B

(OVERALL RESULTS)

SAMPLE SIZE - 47

TRUNK INCLINATION (DEGREES)

	AFTER 2 MIN	AFTER 8 MIN	MOVEMENT	AFTER 2 MIN	AFTER 8 MIN	MOVEMENT
Minimum	88.	89.	0	74	75.	0
Maximum	130.	129.	27.	125	124.5	22.5
Average	108.9	110.	5.5	107	107.6	6.9
Stnd Dev.	10.1	10.3	5.5	10.7	11.0	5.4

TABLE 6. Summary Data for Experimental Groups A & B Showing Trunk Inclination Degrees, and Movement over 2 and 8 minutes.

Data in Table 6 and "Appendix A", show that eighty-four subjects (84/94) in the experimental groups were not sitting with trunk inclination at 90^{o} as prescribed by I.O.S. (1978), after 2 minutes and 8 minutes of work respectively. The within groups analysis also showed the averages of the 2 minutes and 8 minutes preferred working positions, and by comparison with the model established that the majority of subjects in both groups moved over a trunk inclination range during the course of eight minutes of continuous data processing work. In Group A, thirty-two (32/47) subjects moved more than 2 degrees over the period; in Group B, thirty-eight (38/47) subjects moved more than 2 degrees over the period, indicating that the majority of the subjects moved. The third t-distribution was applied to between groups A and B data, and it established there are no statistically significant differences between groups A and B subjects sitting at work after 2 and 8 minutes respectively. That is, statistically the data for both groups can be considered as for one group.

3.4.1 Discussion of Trunk Inclination Results

It is important that only seven subjects in both experimental groups chose to adopt at least one trunk inclination of less than 90 degrees during the course of eight minutes of continuous data processing work. Observation indicates that one female subject sat with trunk inclinations of 74 degrees after 2 minutes and 75 degrees after 8 minutes of work were recorded, the hunched forwards working, kyphotic, preferential posture adopted by the tall german female can be attributed to a preference to sit lower on the chair than prescribed by the model for her trunk and limb anthropometry. It is important that eighty-seven subjects in both experimental groups chose at both measurement intervals to adopt trunk inclinations of greater than 90^{o}.

Grandjean and co-workers, 1983, when examining preferred setting heights by operators of their VDT workstation furniture and equipment, found from 236 observations and 59 subjects a mean trunk inclination to be 104 degrees, with a standard deviation of 6.7 degrees and a minimum-maximum range of 91 degrees to 120 degrees. These results are different to those recorded for experimental groups A and B, but show similarity in that movement occurred and that the means of the subject groups differ from that prescribed by the model.

Grandjean and co-workers, 1981, when performing some laboratory work with seated VDT operators, found primarily that the postural elements measured were of the same order of magnitude as those measured and observed in the field. Secondly, they found that the body postures were characterised by a marked trunk inclination that is, a pronounced backwards leaning. Preference for pronounced backwards leaning is a feature of the data for experimental groups A & B.

SEATED WORKING POSTURE

The ninety-four experimental subjects sat on identical fully adjustable chairs ("Unomanic" form by Co-Design) for their work. The chair type has a fixed horizontal seat pan. For trunk inclination measurements no allowance was made for the positions preferred by the experimental subjects on the available seat cushion. Thus, the thigh was not always presented in the horizontal plane and so the angle presented as "trunk inclination" is a combination of trunk and thigh positions about a centroid of the greater trochanter for each hip.

An interesting variation to the experiment would be the introduction of a seat-tilt version of the fully adjustable chair, with measurements for trunk inclination being taken against a fixed horizontal plane and for thigh inclination taken against a fixed vertical plane.

Illuminance levels in the seated operators hand and eye working zones impacts especially upon trunk inclination because changes in torso position can shield or attract light into the operators primary work zone.

Illuminance readings of operators work stations were not measured during the course of this study, and no experimental group subject complained or commented about their work station lighting. In a field study of 29 experienced operators at a Swedish "Telecom" Enquiry Centre, Shahnavaz and Hedman (1984) measured changes in visual accommodation, workplace lighting and screen source luminance contrasts. The study revealed a low significance relationship between lighting conditions and the incidence of postural changes to accommodate vision. Some operators showed over-visual accommodation - a condition of short-sighting to the source data, which may produce eye strain symptoms and may be an explanation of the desire for some operators to decrease focal distance over time. Shortening of focal distance will vary seated working posture.

3.5 Head Inclination

EXPERIMENTAL GROUP - A EXPERIMENTAL GROUP - B
(OVERALL RESULTS)

SAMPLE SIZE - 47

HEAD INCLINATION (DEGREES)

	AFTER 2 MIN	AFTER 8 MIN	MOVEMENT	AFTER 2 MIN	AFTER 8 MIN	MOVEMENT
Minimum	27.	25.	0	20.	14.	0
Maximum	60.	62.	26.	51.	57.	21.5
Average	43.	43.6	6.4	32.2	29.3	5.7
Stnd Dev.	9.1	9.4	4.9	6.2	8.6	4.7

TABLE 7. Summary Data for Experimental Groups A & B Showing Head Inclination Degrees, and Movement after 2 and 8 minutes.

Data in Table 7 and "Appendix A" show that all ninety-four subjects (94/94) in the experimental groups were not sitting with heads in an up-right, straight-ahead viewing position as prescribed by I.O.S. (1978), after 2 minutes and 8 minutes of work respectively. The within groups analysis also showed the averages of the 2 minutes and 8 minutes preferred working positions, and by comparison with the model established that the majority of subjects moved their heads over a range of degrees during the course of eight minutes of continuous data processing work. In group A, thirty-nine (39/47) subjects moved more than 2 degrees over the period; in group B, thirty-nine (39/47) subjects moved more than 2 degrees over the period, indicating that the majority of subjects moved. The third t-distribution test was applied to between groups A and B data, and it established that there are statistically significant differences between groups A and B subjects sitting at work after 2 and 8 minutes respectively.

3.5.1 Discussion of Head Inclination Results

The "German Square" postural model prescribed by the I.O.S. (1978) document. TC 136/SC7 (1978) gives the geometry of head inclination as zero with the eyes looking forwards in a plane ahead at 180° formed parallel to the seated thighs and at right angles to the upright position of the trunk and head of the seated subject. The anatomical marks prescribed for measuring the head inclination are the C7/T1 spinal joint, the tragion of the ear and an angle formed with a vertical plane. Because the C7/T1 joint in a normally distributed population is approximately 90mm to 100mm in a horizontal plane behind the ear tragion, this means that the head inclination prescribed by the model should be given a value of greater than 0 degrees, probably in the range 45° to 50°. There is insufficient data in "Humanscale" (1978) or within the scientific literature, to confidently predict the range or the mean for head inclination. To conduct a measured survey of head inclination parameters is beyond the scope of this study. On this basis it is not valid to compare the model and the measurements for the experimental groups A and B.

Grandjean and co-workers (1983) when examining preferred work station furniture and equipment settings by VDT operators, found from 236 observations and 59 subjects a mean head inclination of 51 degrees, with a standard deviation of 6.1 degrees, and a minimum - maximum range of 34 to 65 degrees. The results from this study are different in range and mean to those measured for experimental groups A and B, and cannot be explained by the data. The methodology for measurement used by Grandjean and co-workers (1983) was identical to that used to measure head inclinations for subjects in experimental groups A and B. In another study by Grandjean and co-workers (1982) using the same methodology for measurement, 68 subject measurements returned a mean head inclination of 53 degrees.

SEATED WORKING POSTURE

That head working position is influenced by the working trunk position is indicated by comparison of the measured results generated by Grandjean et al (1982, 1983) and by this study. When a backrest column or the trunk itself was altered to increase from 90 degrees to approx 110 degrees subjects exhibit a decrease of the intervertebral disc pressure and of the electromyographic activity of the back (Grandjean et al, 1983). Similar results were observed by Yamaguchi and co-workers (1972), who also advised that an angle between seat and backrest of 115 to 120 degrees provided the best condition for relaxation of the spine. In order for the eyes to then coincide with a near horizontal viewing plane the head must incline or recline in a small range of degrees. Comfortable viewing is achieved by eyes in a cone of vision commencing at approximately 11 degrees below the datum Frankfurt plane of viewing (the imaginary line drawn between the ear tragion and the supraorbital notch of the eye - after Hill and Kroemer, 1986), with declination increasing to approximately 38 degrees below the datum. Therefore, this range of comfortable eye movement is without the necessity to move the cervical vertebral joints of the neck, and indicates that little head inclination is necessary by seated data processing operators who adjust their furniture to meet their preferred postural range. This was observed during the course of measuring group A subjects.

3.6 Arm Flexion

EXPERIMENTAL GROUP - A EXPERIMENTAL GROUP - B

(OVERALL RESULTS)

SAMPLE SIZE - 47

ARM FLEXION (DEGREES)

	AFTER 2 MIN	AFTER 8 MIN	MOVEMENT	AFTER 2 MIN	AFTER 8 MIN	MOVEMENT
Minimum	91.	92.	0	88.5	91.5	0
Maximum	132.	132.	22.	123.	123.5	27.5
Average	105.3	106.6	4.8	103.4	103.8	4.4
Stnd Dev.	7.8	8.3	4.1	7.8	7.4	5.1

TABLE 8. Summary Data for Experimental Groups A & B Showing Arm Flexion Degrees, and Movement after 2 and 8 minutes.

Data in Table 8 and "Appendix A" show that eighty-five subjects (85/94) in the experimental groups were not sitting with upper arms flexed and parallel to the body sides as prescribed by I.O.S. (1978) and "Humanscale" (1974), after 2 minutes and 8 minutes of work respectively. The within groups analysis also showed the averages of the 2 minutes and 8 minutes preferred working positions, and by comparison with the model established that the majority of subjects in both groups moved over an arm flexion range of degrees during the course of eight minutes of continuous data processing work. In group A, thirty-two (32/47) subjects moved more than 2 degrees over the period; in group B, twenty-seven (27/47) subjects moved more than 2 degrees over the period, indicating that the majority of subjects moved. The third t-distribution test was applied to between groups A and B data, and it established that there are no statistically significant differences between groups A and B subjects sitting at work after 2 and 8 minutes respectively. That is, statistically the data for both groups can be considered as for one group.

3.6.1 Discussion of Arm Flexion Results

It is important that only eleven (11) subjects in experimental groups A (2) and B (9) adopted an upper arm flexion of 90 degrees or less. This result means that most subjects preferred to align the upper arm forwards of the position of the seated body sides.

The result may be attributed to a majority operator preference for an inclined trunk for performance of seated work, because in backwards leaning some balance compensation and arm extension to the hand work position is required. This positioning is also compatible to the range of viewing preference demonstrated by the operators. In the findings of Grandjean and co-workers (1983), it was stated that "the upper-arm flexion shows as a nearly normal distribution. The 95% confidence level lies between 103 degrees and 123 degrees. If the upper arms were elevated proportionately to the backward inclination of the trunk, one would expect a mean upper-arm flexion of 104 degrees. In fact, subjects tended to elevate the upper arm to a greater proportionate degree, their mean upper-arm flexion being 113 degrees".

The upper-arm flexion results of Grandjean et al (1981, 1983) are similar to those recorded for experimental groups A and B, but show similarity in that movement occurred and that the means of the subject groups differ from that prescribed by the model. The differences cannot be explained by the data.

Further research into what constitutes intrinsically safe operator comfort and performance parameters for upper-arm flexion, is required.

Keyboard height, profile and angle may be contributing factors to upper-arm flexion results. There is little literature concerning keying performance as a function of keyboard height, slope or keyboard profile.

SEATED WORKING POSTURE

There are several references with regard to keyboard angle, but most of them were written in the 1950-1960 period. These studies were mainly undertaken on mechanical keyboards which demanded a different keyboard angle and slope from modern keyboards (Nelson, 1987).

Cakir et al (1979) states that "to minimise the physiological loading of the hands and to ensure good keying performance, the angle of the keyboard should be between 5 degrees to 15 degrees".

Chapanis (1965) showed that subjectively a 10 degree slope was more comfortable for operators. Keying performance was not affected by this variation in angle.

The recommended angle for modern keyboards (post 1983) should be an approximate range of 5 degrees to 11 degrees the actual angle being determined by its technical aspects, (Knave et al, 1983; Nelson, 1987).

Keyboards used by experimental group A and B subjects were a measured angle range of 7.5 degrees to 12 degrees.

3.7 Upper Arm Abduction from Body Side Distance

EXPERIMENTAL GROUP - A EXPERIMENTAL GROUP - B

(OVERALL RESULTS)

SAMPLE SIZE - 47

UPPER ARM ABDUCTION DISTANCE DEGREES

	AFTER 2 MIN	AFTER 8 MIN	MOVEMENT	AFTER 2 MIN	AFTER 8 MIN	MOVEMENT
Minimum	10.	13.5	0	16.5	13.	0
Maximum	37.	36.5	11.5	40.5	44.	10.5
Average	23.6	24.	2.9	24.9	25.	4.1
Stnd Dev.	6.8	6.2	2.9	5.8	6.1	2.9

TABLE 9. Summary Data for Experimental Groups A & B Showing Upper Arm Abduction Degrees, and Movement after 2 and 8 minutes.

Data in Table 9 and "Appendix A" show that all ninety-four subjects (94/94) in the experimental groups were not sitting with the upper arms parallel to and against the body sides as prescribed by I.O.S. (1978) and "Humanscale" (1974), after 2 minutes and 8 minutes of work respectively. The within groups analysis also showed the averages of the 2 minutes and 8 minutes preferred working positions, and by comparison with the model established that the majority of subjects in both groups moved over an upper arm abduction range of degrees during the course of the 8 minutes of continuous data processing work. In group A, nineteen (19/47) subjects moved more than 2 degrees over the period, in group B, twenty-nine (29/47) subjects moved more than 2 degrees over the period, indicating that the majority of the subjects moved. The third t-distribution test was applied to between groups A and B data, and it established that there are statistically no significant differences between groups A and B subjects sitting at work after 2 and 8 minutes respectively. That is, statistically the data for both groups can be considered as for one group.

3.7.1 Discussion of Upper Arm Abduction Results

Grandjean et al (1983) when examining preferred work station settings by VDT operations, found from 236 observations and 59 subjects a mean preference for upper arm movement away from the body sides to be 22 degrees, with a standard deviation of 7.7 degrees and a minimum - maximum range of 11 to 44 degrees. Grandjean et al (1982) in laboratory experimentation, found for 68 subjects a mean upper arm abduction of 21 degrees. These results are different to those recorded for experimental groups A and B, but show similarity in that movement occurred, and that the means of the subject groups differ from that prescribed by the model. The differences cannot be explained by the data.

Grandjean et al (1983) concluded from field studies that the preferred postures adopted by VDT operators were characterised by a marked trunk inclination, and an increase of both the upper-arm flexions and elbow angles. Upper arm abduction appears to be related to the length of the humeral link and possibly the seated trunk stature. It also may be a function of inappropriately low adjustment by individual operators of the chair seat height. These variables in the anthropometry and the behaviour of subjects in both experimental groups, were observed during the measurement phase of the data collection.

Observation indicates that male subjects (n = Z) of "average" stature, recorded upper-arm abductions near the maximum but the eye heights above floor preferences were less than the averages for the 2 and 8 minutes working position. Thus, for whole body stature, the two subjects are sitting inappropriately low and have compromised relaxed, seated working posture by elevation of the shoulder joints and the elbow joints. Similarly, observation indicates that female subjects (n = 3) of "average", "small" and "tall" stature demonstrate sitting by preference too low to accommodate their upper arms relaxed by their body sides.

Further research into what constitutes intrinsically safe operator comfort and performance parameters for upper-arm abduction from the shoulder acromion process, is required.

3.8 Elbow Angle

EXPERIMENTAL GROUP - A (OVERALL RESULTS) EXPERIMENTAL GROUP - B

SAMPLE SIZE - 47

ELBOW ANGLE (DEGREES)

	AFTER 2 MIN	AFTER 8 MIN	MOVEMENT	AFTER 2 MIN	AFTER 8 MIN	MOVEMENT
Minimum	73.	72.5	0	75.	79.5	0
Maximum	111.	110.	12.	120.5	121.5	32.
Average	90.	90.6	3.8	97.1	97.	7.1
Stnd Dev.	9.1	8.6	2.9	10.7	10.8	7.2

TABLE 10. Summary Data for Experimental Groups A & B Showing Elbow Angle Degrees, and Movements after 2 and 8 minutes.

Data in Table 10 and "Appendix A" show that twenty-four subjects (24/47) in experimental group A sat and worked with the elbow joint at 90^{o} of flexion at the two and eight minutes periods, respectively. However, group B subjects did not adopt the posture prescribed by the I.O.S. (1978) model at either the two or eight minutes period, thirty-two subjects (32/47) sat and worked with elbow joint at less than 88^{o} or at greater than 92^{o}.

The within groups analysis also showed the averages of the 2 minutes and 8 minutes preferred working positions, and by comparison with the model established that the majority of subjects in both groups moved over an elbow angle range during the course of the eight minutes of the data processing work.

The third t-distribution test was applied to between groups A and B data, and it established that there are statistically significant differences between the elbow angles adopted by both groups sitting at work after 2 minutes and 8 minutes respectively. That is, statistically the data for each group cannot be considered the same.

3.8.1 Discussion of Elbow Angle Results

Grandjean et al (1983) when examining preferred work station settings by VDT operators, found that from 236 observations and 59 subjects a mean preferences for elbow angle to be 99 degrees, with a standard deviation of 12.3 degrees, and a minimum - maximum range of 75 degrees to 125 degrees. Grandjean et al (1982) in laboratory experimentation, found for 68 subjects a mean elbow angle of 94 degrees. Both sets of results are different to those recorded for experimental group A and are similar in range only to those recorded for experimental group B. However, all data show movement occurred and the means of three of the subject groups differ from that prescribed by the model.

SEATED WORKING POSTURE

Grandjean and co-workers (1983) found that elbow angle was related to trunk inclination and to upper-arm flexion (forwards movement from the shoulder joint). Their studies (1982, 1983) gave results for elbow angle that were not normally distributed :"... the 95% confidence interval lies between 87 and 111 degrees, and a clear majority of the subjects demonstrated angles between 90 and 110 degrees. Subjects therefore appeared to increase the elbow angle by about 10 degrees when their upper arms were elevated." The latter comment refers to their results for upper arm flexion which were close to a normal distribution. Grandjean et al (1983) stated "that if the upper arms were elevated proportionately to the backward inclination of the trunk one would expect a mean upper-arm flexion of 104 degrees". In fact, Grandjean et al (1983) found that subjects tended to elevate the upper arm to a greater proportionate degree.

The German rules of Verwaltungs Berufsgenossenschaft (authored by Grandjean, 1981) prescribe a hand working height of 750mm above the floor for keyboards on fixed workstations. The German DIN Standard No 4549 (1981) proposed the same hand working height, but prescribed that the desk must be lowered if keyboards higher than 30mm are used. Grandjean et al (1983) commented that these recommendations are based upon anthropometric considerations applied theoretically to upright sitting VDT operators. Grandjean et al (1983) conclude that in practice VDT operators prefer higher keying levels and therefore they do not keep their forearms in a horizontal plane, but in an up-right inclination of approximately 14 degrees.

Preferred elbow angles adopted by VDT operators may be influenced by the tactile feel of the keyboard - characteristics generally inherent in the physical construction, which help the operator to determine that a keystroke has been successfully actioned. (Knave et al, 1983). Unfortunately the predominant research conducted on mechanical keyboards is not applicable because of the difference demonstrated by electronic switches in the key press activation forces, the distances and the direction of the switch travel. (Nelson, 1987; after Knave et al, 1983).

Further research into what constitutes intrinsically safe operator comfort and performance parameters for elbow angles, is required.

3.9 Left Wrist-Joint Ulnar Abduction

EXPERIMENTAL GROUP - A EXPERIMENTAL GROUP - B

(OVERALL RESULTS)

SAMPLE SIZE - 47

LEFT WRIST-JOINT ULNAR ABDUCTION (DEGREES)

	AFTER 2 MIN	AFTER 8 MIN	MOVEMENT	AFTER 2 MIN	AFTER 8 MIN	MOVEMENT
Minimum	0.	0	0	0	0	0
Maximum	23.	16.5	12.0	32.	23.5	12.5
Average	5.1	5.1	2.3	10.4	11.1	3.3
Stnd Dev.	5.0	4.2	2.6	5.6	5.4	2.8

TABLE 11. Summary Data for Experimental Groups A & B Showing Left Wrist Ulnar Abduction Degrees, and Movement after 2 and 8 minutes.

Data in Table 11 show that sixty subjects (60/94) in the experimental groups (A; n = 17 & B; n = 43) were not sitting with the left wrist joint and hand in a neutral position as presumed to be the model prescribed by I.O.S. (1978) and supported by "Humanscale" (1974), after 2 minutes and 8 minutes of work respectively. The within groups analysis also showed the averages of the 2 minutes and 8 minutes preferred working positions, and by comparison with the model established that a total of forty-five (45/94) subjects in both groups moved and deviated about the ulnar styloid process of the left wrist joint during the course of eight minutes of continuous data processing work. In group A, fifteen (15/47) subjects moved more than 2 degrees over the period; in group B, thirty (30/47) subjects moved more than 2 degrees over the period, indicating that the majority of subjects in group B only moved. The third t-distribution test was applied to between experimental groups A and B data, and it established that there are statistically significant differences between groups A and B subjects sitting at work after 2 and 8 minutes respectively. That is, statistically the data for each group cannot be considered the same.

3.9.1 Discussion of Left Wrist-Joint Ulnar Abduction Results

The postural model prescribed by IOS (1978) presents the wrist joints, hands and forearms in a straight-line and not in a neutral or relaxed position to commence keying or writing work. No value of degrees of deviation or normality is presented by the model. The presentation of the wrist joint posture appears to be contrary to the findings of NASA (1978) in their weightlessness effects and neutral body anthropometric measurements.

The technique for measuring ulnar abduction as the angle formed along the anterior plane of the thumb to the meeting point of the radial styloid process, and to the distal digit of the middle finger forming a line along the capitate and metacarpal bones (hand in the pronated position), requires a value in degrees for neutral position.

There is insufficient data in "Humanscale" (1978) or within the scientific literature, to confidently predict the range or the mean for head inclination or left wrist-joint ulnar abduction for a normally distributed adult population.

The ulnar deviations measured for most subjects within the two groups were consistently close to the numeric averages for each group, that is group A approximately 5 degrees and group B approximately 10.5 degrees. The differences cannot be explained by the data.

Grandjean et al (1983) when reporting preferred settings of VDT workstations, for ulnar abduction category from 236 observations and 59 subjects recorded a mean preference of 9 degrees, a standard deviation of 5.5 degrees and a minimum - maximum range of 0 to 20 degrees. These results are between those recorded for experimental groups A and B, but the results cannot be explained by the data. Grandjean et al (1982, 1983) reported that ulnar abduction results in laboratory and field studies disclosed less important changes than the other postural elements of trunk, head, elbow and upper arm positions.

It is notable that the keyboard used by subjects in experimental group A was a two-handed, split-field type with a key top layout based upon the anthropometry of the pronated hand; experimental group B subjects used an oblong standard QWERTY layout keyboard.

There is little literature concerning keying performance as a function of working posture, or of keyboard slope or keyboard profile and working posture. Current keyboards are either stepped, sloped or dished and as a consequence of great variety little information is available about the relative advantages of such profiles (Nelson, 1987).

Rose (1985) reported that finger operating posture in keyboard use is compromised with straight key-rows not matching different finger lengths, and when the hands are at maximum pronation the fingers present at an angle to the horizontal. The postural compromise to activate the keys includes wrist joint ulnar deviation, and forces the fingers, wrist-joints and forearm muscles into constraint with a static muscle overlay.

3.10 Complete statistical evaluation of t-distribution within and between group measurements

i. Within group measured comparisons of the preferential seated working posture and that prescribed by the model after 2 and 8 minutes respectively -

Ho, u = model
Hi, u = model

CATEGORY	SIGNIFICANCE AFTER 2 MINS	SIGNIFICANCE AFTER 8 MINS
EYE/FLOOR DISTANCE	GROUP A	
	< .01 **	< .01 **
	GROUP B	
	< .10 *	< .10 *
ACROMION/ KEYBOARD	GROUP A	
	< .01 **	< .01 **
	GROUP B	
	< .01 **	< .01 **
EYE/COPY DISTANCE	GROUP A	
	< .01 **	< .01 **
	GROUP B	
	< .01 **	< .01 **

SEATED WORKING POSTURE

CATEGORY	SIGNIFICANCE AFTER 2 MINS	SIGNIFICANCE AFTER 8 MINS
TRUNK INCLINATION	GROUP A < .01 **	< .01 **
	GROUP B < .01 **	< .01 **
HEAD INCLINATION	GROUP A < .01 **	< .01 **
	GROUP B < .01 **	< .01 **
ARM FLEXION	GROUP A < .01 **	< .01 **
	GROUP B < .01 **	< .01 **
ARM ABDUCTION	GROUP A < .01 **	< .01 **
	GROUP B < .01 **	< .01 **

SEATED WORKING POSTURE

CATEGORY	SIGNIFICANCE AFTER 2 MINS	SIGNIFICANCE AFTER 8 MINS
ELBOW ANGLE	GROUP A NO SIGNIFICANCE	NO SIGNIFICANCE
	GROUP B < .01 **	< .01 **
LEFT ULNAR ABDUCTION	GROUP A < .01 **	< .01 **
	GROUP B < .01 **	< .01 **

TABLE 12 - Statistical Summaries of t-Distribution Within Groups, for the Nine Categories of Measurements.

ii. Within group measured comparisons of postural changes preferred by the operators at the 2 and 8 minutes positions, compared against the model -

Ho, u at 2 minutes = u at 8 minutes

Hi, u at 2 minutes = u at 8 minutes

CATEGORY	SIGNIFICANCE 2 & 8 MINUTES AVERAGES	CATEGORY	SIGNIFICANCE 2 & 8 MINUTES AVERAGES
EYE/FLOOR DISTANCE	GROUP A < .01 ** GROUP B < .01 **	ACROMION/ KEYBOARD DISTANCE	GROUP A < .01 ** GROUP B < .01 **
EYE/COPY DISTANCE	GROUP A < .01 ** GROUP B < .01 **	TRUNK INCLINATION	GROUP A < .01 ** GROUP B < .01 **
HEAD INCLINATION	GROUP A < .01 ** GROUP B < .01 **	ARM FLEXION	GROUP A < .01 ** GROUP B < .01 **

SEATED WORKING POSTURE

CATEGORY	SIGNIFICANCE 2 & 8 MINUTES AVERAGES	CATEGORY	SIGNIFICANCE 2 & 8 MINUTES AVERAGES
ARM ABDUCTION	GROUP A < .01 ** GROUP B < .01 **	ELBOW ANGLE	GROUP A < .01 ** GROUP B < .01 **
LEFT ULNAR ABDUCTION	GROUP A < .01 ** GROUP B < .01 **		

TABLE 13 - Statistical Summaries of the t-Distribution Within Groups, for 9 categories of measurements.

SEATED WORKING POSTURE

iii. Between groups comparison to establish whether or not experimental group A data is different to experimental group B data -

Ho, uA = uB

Hi, uA = uB

CATEGORY	SIGNIFICANCE AT 2 MINUTES POSITIONS	SIGNIFICANCE AT 8 MINUTES POSITIONS
EYE/FLOOR DISTANCE	< .01 **	< .01 **
ACROMION/ KEYBOARD DISTANCE	< .01 **	< .01 **
EYE/COPY DISTANCE	< .01 **	< .01 **
TRUNK INCLINATION	NO SIGNIFICANCE	NO SIGNIFICANCE
HEAD INCLINATION	< .01 **	< .01 **
ARM FLEXION	< .10 *	< .10 *

SEATED WORKING POSTURE

CATEGORY	SIGNIFICANCE AT 2 MINUTES POSITIONS	SIGNIFICANCE AT 8 MINUTES POSITIONS
ARM ABDUCTION	NO SIGNIFICANCE	NO SIGNIFICANCE
ELBOW ANGLE	< .01 **	NO SIGNIFICANCE
LEFT ULNAR ABDUCTION	< .01 **	< .01 **

Because the null hypothesis was not predominant, group A and group B data was analysed separately, for tests (i) and (ii).

TABLE 14 - Statistical Summaries of t-Distribution Between Groups, for Nine Categories of Measurements.

3.11 Summary of "Mean Body Posture" at the Operators Preferred Settings, at 2 minutes and 8 minutes positions, groups A and B.

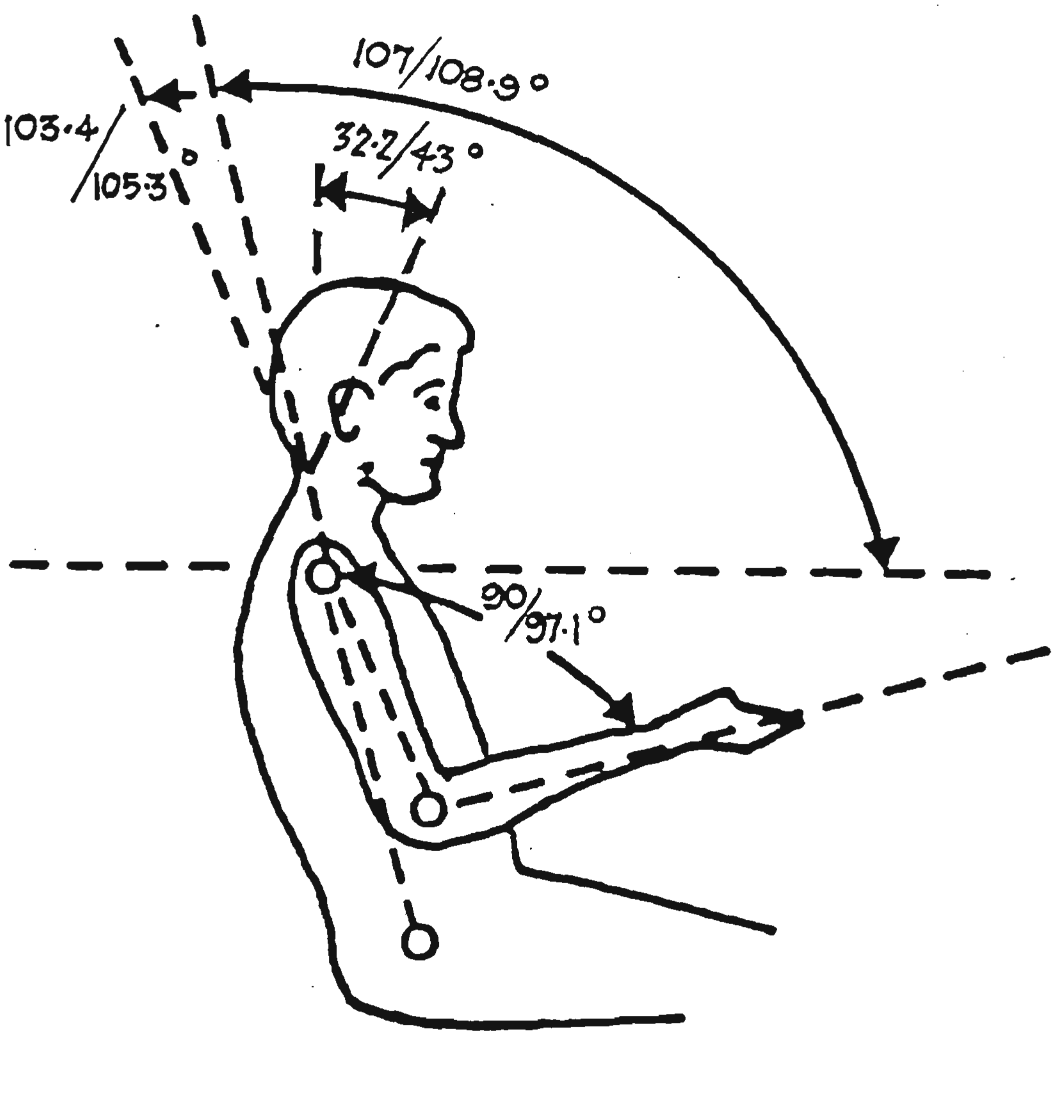

FIGURE 23. Sagittal Plane Projection of Mean from Measured Range of Operators Preferred Trunk Inclinations, Head Inclinations, Arm Flexions, and Elbow Angles.

Adapted from Grandjean et al, 1983.

3.12 Summary Discussion of graphical results for Nine Categories of Measurement

Histograms for each of the nine categories of measurement and for each experimental group, are presented in parallel graphics form to compare behaviour. The bar projections for each group represent the numerical averages of each particular working position at the 2 and 8 minutes measurement points. The histograms are "Appendix B" to the paper. The histograms clearly show overall similarities in behaviour between groups, and show absolutely that the experimental subjects in both groups did not adopt the training elements of the "German Square" postural model.

Scattergrams for each of the nine categories of measurement and for each experimental group, are presented as actual measurements at the 2 and 8 minutes measurement points for comparative purposes to judge individual movements observed. The scattergrams include "line of best fit" projections based on the 2 minutes observation positions and the measurement tolerances of ± 5mm and ± 2 degrees. The scattergrams are "Appendix C" to the paper. The scattergrams clearly show the consistency and the range of movement within groups. The movements of individual subjects over time are contrary to the "sit still" rules of the "German Square" postural model.

Relationship graphs depicting the three lineal categories of measurement are shown separately each in single relationship to all six of the angular measurements. Averages of the 2 and 8 minutes positions have been plotted. Results are presented separately for each experimental group, and for clarification "line of best fit" projections follow each of the graphs. Relationship graphs are "Appendix D" to the paper. Between groups comparisons indicate similarity in behaviour over observed time. The preferred seated working postures adopted by the experimental group subjects do not correlate closely to the seated postural geometry shown and described in the "German Square" model.

Relationship graphs comparing subject stature against the angular measurements of trunk inclinations, head inclinations, arm flexions and elbow angles, are "Appendix E" to the paper. Separate graphs have been plotted for experimental groups A and B and each plot is followed by a "line of best fit" projection for clarification of the relationships (if any exists). The relationship projections associate an increase in subject stature with increase in head inclination, and slight decrease in trunk inclination with increase in subject stature. The results of these relationship tests are inconclusive due to the relatively small numbers of population sampled and the uniqueness of the tests. Clearly, the results show that a range of angular postures are preferred by seated operators performing data processing work, and these postures are not closely allied to the trunk upright and ninety degree limbs geometry position.

Relationship graphs comparing lineal categories of measurement have been plotted viz, eye to floor heights and shoulder acromion process heights above the keyboard; eye to floor heights and eye to copy distances; eye to copy distances and shoulder acromion process heights above the keyboard. The relationship graphs are shown as "Appendix F" to the paper.

The relationships are depicted in linear graphics with "line of best fit" projections for clarification. All relationships show a positive association, that is, as one parameter increases then the others also increase.

The results of these relationship tests are inconclusive due to the relatively small numbers of population sampled and the uniqueness of the tests. Clearly, the results show a linear relationship in seated working postures that do not follow the upright trunk and ninety degree limbs posture prescribed by the "German Square" model.

Of interest are the various relationships one to another; a feature of the data is the consistency of adoption by the experimental subjects of reclined seated working postures that differ markedly to those prescribed by the "German Square" postural model. The postural inter-relationships are an interesting area of science which require further investigation, and are not further discussed in the body of the paper.

4. CONCLUSIONS

There is considerable speculation about the nature of seated working posture. The opportunities and the restraints the operators who perform data processing work have imposed on them during the course of the work, to promote or prevent fatigue and discomfort, are not scientifically elucidated. Research interests in the areas of seated working posture are isolated to small numbers of medical and health professionals who have concentrated enquiry into physiological matters of the seated working position. (Mandal, 1985).

For seated data process work (and all other sedentary occupations) it is essential that the design of the workstation and the ancillary equipment incorporates the best human factors knowledge available. That research continues and is organised into an holistic approach is vital to determine what comprises a comfortable and intrinsically safe seated working posture. The research must attempt to explain the relationships between the nine elements of postural position and other elements that may arise by association, discussed within this paper. Explanation of any relationship between seated operator comfort, performance at the task and operator seated postural preference must also be determined.

Important is the need to ensure that designers, manufacturers of workstation furniture and ancillary equipment and the procurers of all such equipment understand what is meant by 'the best ergonomic features' required to enhance appropriate seated working posture. This can only be achieved through scientific research and the promotion and spread of the knowledge gleaned from the work. This is a dynamic process changing as knowledge increases.

SEATED WORKING POSTURE

This study reviewed the scientific literature for seated working posture and examined the standards that purport to be based on it and found those standards inadequate in technical content based on the current body of scientific knowledge. In an attempt to improve the position, a research method conducted in the workplace setting was undertaken to examine and evaluate nine aspects of seated postural comfort and performance. The study found operators sat dynamically and adopted very different ranges of preferred seated body positions to those prescribed by the "German Square" postural model. These findings confirmed by the impressions of many observers of seated working posture (Grandjean et al 1982, 83), indicate that seated data processor operators do not maintain an up-right trunk posture.

The null hypothesis that operators prefer to adopt very different seated postural positions to those prescribed and administered in training based on the "German Square" seated postural model, is proved.

Unfortunately, the call for information from the mid 1970's promoted by the revolution of CRT based information processing systems, has fostered a generation of standards that are used internationally to promote an upright trunk, 90 degree limb geometry, looking straight ahead, static, seated working posture. Such standards culminated in, and are typified by the International Organisation for Standardisation document TC 136/SC7, published in 1978. These documents contain anecdotal and "state-of-the-art" information which is not based in good scientific principles.

These documents may or may not specify the requirements for seated working posture numerically and/or in degrees, or may use loose terminology such as "the operator must be seated comfortably" and are accompanied by a sagittal plane sketch showing the "German Square" geometric elements of a seated working position. As it is not known scientifically what constitutes comfortable, and intrinsically safe working posture, or what significance each of the elements of posture has, it is preferable to use descriptive terminology based upon the body of knowledge found in the scientific literature. The use of numerical data can imply to the recipient that the data are sound, which may not be the case. The appropriate judge of seated postural comfort is likely to be the experienced data processor operator, and once instructed to consider qualities in the range known for preferred seated working posture adequate subjective information maybe fed-back to the researchers. However, it should be the requirement for objectivity on the part of those setting standards, that creates the need for further research to be conducted into comfortable and intrinsically safe, seated working posture. This has important implications for the training and supervision of seated workers.

It is against this background of uncertainty and incomplete agreement among authorities that comparative data have been generated in this study by field research and the results evaluated against the model published by I.O.S. (1978), and complimented by "Humanscale" (1974). The evaluation included 9 categories of seated working postural elements that may contribute to seated working comfort and performance by data processor operators. It is cautioned that the ranges measured for some of the categories, viz, eye to screen distance, shoulder acromion to keyboard home row height, elbow angle and wrist-joint ulnar abduction, are wide and misinterpretable. The comparisons between the model and the experimental results for the head inclination category are invalid, due to an incorrect anatomical interpretation by the "German Square" postural specification, and should not be utilised in practice.

SEATED WORKING POSTURE

As it can be shown that certain workstation furniture and equipment design criteria affect seated operator comfort and performance, then there is an ergonomic and an economic incentive to produce furniture and equipment that include scientifically ascertained design criteria. Only with reliable data from scientific research into what constitutes a comfortable and intrinsically safe working posture, can this goal be achieved. Trade unions, employers, users, buyers and insurers will demand products evolved in this way and manufacturers will hasten to meet such demand.

At the time of writing, the Standards Association of Australia published a standard for visual display terminals (AS 3590.2-1990, "Screen-based workstations Part 2: Workstation furniture) which included consideration of the postural aspects required for seated work viewing to a CRT screen and using a keyboard. The Association relied upon the opinions, standards and the research that has been produced in other countries because of the paucity of research conducted locally. The I.O.S. (1978) "German Square" postural model was not challenged by this standard and was embodied without contradiction within the document.

4. BIBLIOGRAPHY

During the investigation into aspects of seated working posture, many references have been noted which have some relevance to the thrust of the research.

Because of the numbers of and variation within the scientific disciplines involved, it is not claimed that the bibliography is complete. The sources listed are those which the author has found useful in providing the substantial background information required for the investigation and research undertaken in this study.

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SEATED WORKING POSTURE

\- A Research Thesis with
Experimental Methodology
and Literature Review

SUBMITTED BY:-

DAVID STANTON PATRICK NELSON
for
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APPENDICES

APPENDICES

APPENDIX A - Separate Tabular Summaries for Experimental Groups A and B, showing the results for:-

- eye to floor measurements;
- shoulder acromion to keyboard home row heights;
- eye to copy distances;
- trunk inclinations;
- head inclinations;
- upper arm flexions from the shoulder joints;
- arm abductions from the body sides;
- elbow angles;
- left wrist-joint ulnar abductions.

DATA BASE EXPERIMENTAL GROUP - A

(TABLES)

EXPERIMENTAL GROUP - A (OVERALL)
SAMPLE SIZE - 47

CODE	ORIGIN	SEX	AGE	HGHT	MASS	EYE/FLOOR DISTANCE 2 MIN	8 MIN	MOVEMEN
E1	AUST	M	23	1880	85.0	1220	1230	10
E2	AUST	M	22	1810	80.0	1257	1245	12
E3	AUST	M	22	1810	77.0	1238	1244	6
E4	AUST	M	28	1759	79.0	1226	1222	4
E5	AUST	F	21	1645	76.3	1208	1218	10
E6	AUST	F	30	1708	60.5	1248	1245	3
E7	AUST	M	27	1880	74.7	1267	1268	1
E8	AUST	F	26	1568	61.0	1240	1241	1
E9	AUST	M	28	1798	76.0	1282	1282	0
E10	AUST	M	29	1836	89.0	1270	1279	9
E11	AUST	F	26	1696	60.0	1253	1249	4
E12	AUST	F	21	1630	64.0	1261	1259	2
E13	ABOR	M	25	1734	61.0	1284	1265	19
E14	AUST	M	32	1734	67.0	1258	1249	9
E15	AUST	M	25	1683	60.0	1252	1256	4
E16	AUST	M	26	1640	65.5	1245	1248	3
E17	S.AM	F	42	1570	70.0	1241	1244	3
E18	AUST	M	36	1747	100.0	1252	1247	5
E19	ASIA	M	32	1600	50.0	1208	1224	16
E21	AUST	M	45	1938	75.0	1300	1285	15
E22	ENGL	F	35	1683	67.0	1290	1285	5
E26	VIET	F	42	1620	60.0	1238	1252	14
E27	AUST	M	32	1759	89.0	1248	1248	0
E28	AUST	M	27	1734	60.0	1258	1248	10
E29	AUST	M	26	1785	62.0	1291	1242	49
E30	VIET	M	35	1720	74.0	1278	1270	8
E31	AUST	M	30	1816	80.0	1218	1212	6
E32	AUST	M	39	1874	66.0	1228	1230	2
E33	AUST	F	25	1606	69.0	1184	1259	75
E34	ASIA	F	28	1581	60.0	1220	1235	15
E35	ASIA	F	35	1555	49.0	1250	1250	0
E36	AUST	F	29	1606	89.0	1240	1245	5
E37	ASIA	M	45	1700	70.0	1215	1212	3
E38	AUST	M	38	1747	86.0	1260	1260	0
E39	ASIA	M	36	1750	64.0	1220	1220	0
E40	ASIA	M	30	1650	64.0	1210	1207	3
E41	ASIA	M	33	1610	52.0	1230	1240	10
E42	AUST	F	30	1658	60.0	1200	1200	0
E43	POLI	F	26	1747	86.0	1178	1180	2
E44	CHIN	F	25	1680	74.0	1210	1210	0
E45	CHIN	M	28	1606	66.0	1243	1218	25
E46	VIET	F	29	1580	51.0	1190	1206	16
E47	CHIN	F	29	1630	59.0	1220	1230	10
E48	CHIN	M	50	1665	53.0	1248	1238	10
E49	PHIL	M	23	1730	62.0	1212	1243	31
E52	VIET	M	31	1740	86.0	1222	1232	10
E54	AUST	M	51	1700	65.0	1269	1260	9
MINIMUM			21	1555	49.0	1178	1180	0
MAXIMUM			51	1938	100.0	1300	1285	75
AVERAGE			31	1706	69.2	1240	1241	10
STD DEV			7.2	92.6	11.8	28.5	22.8	13.2
VARIANCE			52	8578	139	810	519	173

PERIMENTAL GROUP - A (OVERALL)
MPLE SIZE - 47

DE	ORIGIN	SEX	AGE	HGHT	MASS	ACROMION/KEYBOARD DISTANCE 2 MIN	8 MIN	MOVEMEN
	AUST	M	23	1880	85.0	285	260	25
	AUST	M	22	1810	80.0	255	252	3
	AUST	M	22	1810	77.0	252	242	10
	AUST	M	28	1759	79.0	214	218	4
	AUST	F	21	1645	76.3	232	223	9
	AUST	F	30	1708	60.5	218	228	10
	AUST	M	27	1880	74.7	229	241	12
	AUST	F	26	1568	61.0	268	249	19
	AUST	M	28	1798	76.0	271	265	6
0	AUST	M	29	1836	89.0	264	268	4
1	AUST	F	26	1696	60.0	270	257	13
2	AUST	F	21	1630	64.0	222	222	0
3	ABOR	M	25	1734	61.0	243	255	12
4	AUST	M	32	1734	67.0	284	278	6
5	AUST	M	25	1683	60.0	287	294	7
6	AUST	M	26	1640	65.5	252	252	0
7	S.AM	F	42	1570	70.0	240	230	10
8	AUST	M	36	1747	100.0	268	290	22
9	ASIA	M	32	1600	50.0	208	215	7
1	AUST	M	45	1938	75.0	304	320	16
2	ENGL	F	35	1683	67.0	310	285	25
5	VIET	F	42	1620	60.0	250	260	10
7	AUST	M	32	1759	89.0	280	292	12
8	AUST	M	27	1734	60.0	248	240	8
9	AUST	M	26	1785	62.0	288	256	32
0	VIET	M	35	1720	74.0	284	308	24
1	AUST	M	30	1816	80.0	190	198	8
2	AUST	M	39	1874	66.0	224	214	10
3	AUST	F	25	1606	69.0	212	222	10
4	ASIA	F	28	1581	60.0	210	215	5
5	ASIA	F	35	1555	49.0	255	255	0
6	AUST	F	29	1606	89.0	240	250	10
7	ASIA	M	45	1700	70.0	230	225	5
8	AUST	M	38	1747	86.0	323	321	2
9	ASIA	M	36	1750	64.0	240	235	5
0	ASIA	M	30	1650	64.0	206	205	1
1	ASIA	M	33	1610	52.0	240	250	10
2	AUST	F	30	1658	60.0	220	220	0
3	POLI	F	26	1747	86.0	225	230	5
4	CHIN	F	25	1680	74.0	218	195	23
5	CHIN	M	28	1606	66.0	182	184	2
6	VIET	F	29	1580	51.0	178	205	27
7	CHIN	F	29	1630	59.0	182	195	13
8	CHIN	M	50	1665	53.0	276	258	18
9	PHIL	M	23	1730	62.0	232	255	23
2	VIET	M	31	1740	86.0	196	225	29
4	AUST	M	51	1700	65.0	278	268	10
NIMUM			21	1555	49.0	178	184	0
XIMUM			51	1938	100.0	323	321	32
ERAGE			31	1706	69.2	244	245	11
D DEV			7.2	92.6	11.8	34.7	32.3	8.4
RIANCE			52	8578	139	1207	1042	70

EXPERIMENTAL GROUP - A (OVERALL)
SAMPLE SIZE - 47

CODE	ORIGIN	SEX	AGE	HGHT	MASS	EYE/COPY DISTANCE 2 MIN	8 MIN	MOVEMEN
E1	AUST	M	23	1880	85.0	550	555	5
E2	AUST	M	22	1810	80.0	708	730	22
E3	AUST	M	22	1810	77.0	600	605	5
E4	AUST	M	28	1759	79.0	610	610	0
E5	AUST	F	21	1645	76.3	648	670	22
E6	AUST	F	30	1708	60.5	680	698	18
E7	AUST	M	27	1880	74.7	668	651	17
E8	AUST	F	26	1568	61.0	657	657	0
E9	AUST	M	28	1798	76.0	784	800	16
E10	AUST	M	29	1836	89.0	698	703	5
E11	AUST	F	26	1696	60.0	661	650	11
E12	AUST	F	21	1630	64.0	704	703	1
E13	ABOR	M	25	1734	61.0	770	795	25
E14	AUST	M	32	1734	67.0	650	630	20
E15	AUST	M	25	1683	60.0	622	615	7
E16	AUST	M	26	1640	65.5	678	675	3
E17	S.AM	F	42	1570	70.0	645	620	25
E18	AUST	M	36	1747	100.0	730	720	10
E19	ASIA	M	32	1600	50.0	675	685	10
E21	AUST	M	45	1938	75.0	710	670	40
E22	ENGL	F	35	1683	67.0	650	640	10
E26	VIET	F	42	1620	60.0	787	740	47
E27	AUST	M	32	1759	89.0	690	715	25
E28	AUST	M	27	1734	60.0	670	648	22
E29	AUST	M	26	1785	62.0	725	718	7
E30	VIET	M	35	1720	74.0	725	728	3
E31	AUST	M	30	1816	80.0	685	698	13
E32	AUST	M	39	1874	66.0	670	675	5
E33	AUST	F	25	1606	69.0	700	705	5
E34	ASIA	F	28	1581	60.0	650	700	50
E35	ASIA	F	35	1555	49.0	660	660	0
E36	AUST	F	29	1606	89.0	660	690	30
E37	ASIA	M	45	1700	70.0	650	655	5
E38	AUST	M	38	1747	86.0	750	748	2
E39	ASIA	M	36	1750	64.0	665	663	2
E40	ASIA	M	30	1650	64.0	656	690	34
E41	ASIA	M	33	1610	52.0	620	630	10
E42	AUST	F	30	1658	60.0	670	665	5
E43	POLI	F	26	1747	86.0	710	690	20
E44	CHIN	F	25	1680	74.0	630	552	78
E45	CHIN	M	28	1606	66.0	583	655	72
E46	VIET	F	29	1580	51.0	570	565	5
E47	CHIN	F	29	1630	59.0	725	665	60
E48	CHIN	M	50	1665	53.0	628	621	7
E49	PHIL	M	23	1730	62.0	610	618	8
E52	VIET	M	31	1740	86.0	643	652	9
E54	AUST	M	51	1700	65.0	680	692	12
MINIMUM			21	1555	49.0	550	552	0
MAXIMUM			51	1938	100.0	787	800	78
AVERAGE			31	1706	69.2	670	671	17
STD DEV			7.2	92.6	11.8	50.6	52.2	18.3
VARIANCE			52	8579	139	2564	2728	334

EXPERIMENTAL GROUP - A (OVERALL)
SAMPLE SIZE - 47

CODE	ORIGIN	SEX	AGE	HGHT	MASS	TRUNK INCLINATION 2 MIN	8 MIN	MOVEMEN
E1	AUST	M	23	1880	85.0	89.0	91.0	2.0
E2	AUST	M	22	1810	80.0	101.0	101.0	0.0
E3	AUST	M	22	1810	77.0	106.0	103.5	2.5
E4	AUST	M	28	1759	79.0	101.5	96.0	5.5
E5	AUST	F	21	1645	76.3	116.0	112.0	4.0
E6	AUST	F	30	1708	60.5	105.0	110.5	5.5
E7	AUST	M	27	1880	74.7	117.5	120.5	3.0
E8	AUST	F	26	1568	61.0	102.5	110.0	7.5
E9	AUST	M	28	1798	76.0	117.0	115.5	1.5
E10	AUST	M	29	1836	89.0	104.5	103.5	1.0
E11	AUST	F	26	1696	60.0	109.0	107.5	1.5
E12	AUST	F	21	1630	64.0	96.5	103.0	6.5
E13	ABOR	M	25	1734	61.0	116.0	115.0	1.0
E14	AUST	M	32	1734	67.0	116.5	117.5	1.0
E15	AUST	M	25	1683	60.0	108.0	101.0	7.0
E16	AUST	M	26	1640	65.5	119.0	116.0	3.0
E17	S.AM	F	42	1570	70.0	102.5	111.5	9.0
E18	AUST	M	36	1747	100.0	118.0	111.0	7.0
E19	ASIA	M	32	1600	50.0	100.0	100.0	0.0
E21	AUST	M	45	1938	75.0	99.0	105.0	6.0
E22	ENGL	F	35	1683	67.0	115.0	115.0	0.0
E26	VIET	F	42	1620	60.0	128.0	124.0	4.0
E27	AUST	M	32	1759	89.0	115.5	111.0	4.5
E28	AUST	M	27	1734	60.0	103.5	102.0	1.5
E29	AUST	M	26	1785	62.0	115.0	123.0	8.0
E30	VIET	M	35	1720	74.0	120.5	123.5	3.0
E31	AUST	M	30	1816	80.0	91.5	97.0	5.5
E32	AUST	M	39	1874	66.0	89.0	89.0	0.0
E33	AUST	F	25	1606	69.0	109.0	116.0	7.0
E34	ASIA	F	28	1581	60.0	103.0	123.0	20.0
E35	ASIA	F	35	1555	49.0	113.0	112.5	0.5
E36	AUST	F	29	1606	89.0	88.0	98.0	10.0
E37	ASIA	M	45	1700	70.0	130.0	125.0	5.0
E38	AUST	M	38	1747	86.0	119.0	120.0	1.0
E39	ASIA	M	36	1750	64.0	124.0	125.0	1.0
E40	ASIA	M	30	1650	64.0	108.0	98.5	9.5
E41	ASIA	M	33	1610	52.0	123.0	119.0	4.0
E42	AUST	F	30	1658	60.0	115.0	115.5	0.5
E43	POLI	F	26	1747	86.0	113.5	118.0	4.5
E44	CHIN	F	25	1680	74.0	92.0	102.0	10.0
E45	CHIN	M	28	1606	66.0	108.0	114.0	6.0
E46	VIET	F	29	1580	51.0	103.5	92.5	11.0
E47	CHIN	F	29	1630	59.0	99.5	109.0	9.5
E48	CHIN	M	50	1665	53.0	112.0	120.0	8.0
E49	PHIL	M	23	1730	62.0	108.5	129.0	20.5
E52	VIET	M	31	1740	86.0	117.0	90.0	27.0
E54	AUST	M	51	1700	65.0	110.0	112.5	2.5
MINIMUM			21	1555	49.0	88.0	89.0	0.0
MAXIMUM			51	1938	100.0	130.0	129.0	27.0
AVERAGE			31	1706	69.2	108.9	110.1	5.5
STD DEV			7.2	92.6	11.8	10.1	10.3	5.5
VARIANCE			52	8578	139	102	106	30

EXPERIMENTAL GROUP - A (OVERALL)
SAMPLE SIZE - 47

CODE	ORIGIN	SEX	AGE	HGHT	MASS	HEAD INCLINATION 2 MIN	8 MIN	MOVEMEN
E1	AUST	M	23	1880	85.0	35.0	51.0	16.0
E2	AUST	M	22	1810	80.0	38.0	43.0	5.0
E3	AUST	M	22	1810	77.0	38.0	35.0	3.0
E4	AUST	M	28	1759	79.0	41.5	31.0	10.5
E5	AUST	F	21	1645	76.3	40.5	32.5	8.0
E6	AUST	F	30	1708	60.5	37.0	37.0	0.0
E7	AUST	M	27	1880	74.7	42.5	36.0	6.5
E8	AUST	F	26	1568	61.0	27.5	37.5	10.0
E9	AUST	M	28	1798	76.0	30.0	39.5	9.5
E10	AUST	M	29	1836	89.0	27.0	33.5	6.5
E11	AUST	F	26	1696	60.0	32.5	30.5	2.0
E12	AUST	F	21	1630	64.0	28.5	31.0	2.5
E13	ABOR	M	25	1734	61.0	47.0	44.0	3.0
E14	AUST	M	32	1734	67.0	47.0	54.5	7.5
E15	AUST	M	25	1683	60.0	46.0	57.0	11.0
E16	AUST	M	26	1640	65.5	57.5	51.0	6.5
E17	S.AM	F	42	1570	70.0	45.5	44.5	1.0
E18	AUST	M	36	1747	100.0	58.0	62.0	4.0
E19	ASIA	M	32	1600	50.0	38.0	40.0	2.0
E21	AUST	M	45	1938	75.0	48.0	55.0	7.0
E22	ENGL	F	35	1683	67.0	48.0	52.0	4.0
E26	VIET	F	42	1620	60.0	43.5	43.5	0.0
E27	AUST	M	32	1759	89.0	47.0	49.5	2.5
E28	AUST	M	27	1734	60.0	48.5	50.5	2.0
E29	AUST	M	26	1785	62.0	49.0	45.5	3.5
E30	VIET	M	35	1720	74.0	42.0	43.5	1.5
E31	AUST	M	30	1816	80.0	48.0	50.0	2.0
E32	AUST	M	39	1874	66.0	48.5	45.0	3.5
E33	AUST	F	25	1606	69.0	52.0	56.0	4.0
E34	ASIA	F	28	1581	60.0	40.0	31.0	9.0
E35	ASIA	F	35	1555	49.0	28.0	45.0	17.0
E36	AUST	F	29	1606	89.0	48.0	38.0	10.0
E37	ASIA	M	45	1700	70.0	51.0	55.0	4.0
E38	AUST	M	38	1747	86.0	48.0	55.0	7.0
E39	ASIA	M	36	1750	64.0	60.0	57.0	3.0
E40	ASIA	M	30	1650	64.0	47.5	56.0	8.5
E41	ASIA	M	33	1610	52.0	39.0	46.7	7.7
E42	AUST	F	30	1658	60.0	54.0	57.0	3.0
E43	POLI	F	26	1747	86.0	52.0	39.0	13.0
E44	CHIN	F	25	1680	74.0	55.0	50.5	4.5
E45	CHIN	M	28	1606	66.0	56.0	42.5	13.5
E46	VIET	F	29	1580	51.0	53.0	27.0	26.0
E47	CHIN	F	29	1630	59.0	30.0	32.5	2.5
E48	CHIN	M	50	1665	53.0	35.0	39.0	4.0
E49	PHIL	M	23	1730	62.0	32.5	39.0	6.5
E52	VIET	M	31	1740	86.0	27.0	33.0	6.0
E54	AUST	M	51	1700	65.0	35.0	25.0	10.0
MINIMUM			21	1555	49.0	27.0	25.0	0.0
MAXIMUM			51	1938	100.0	60.0	62.0	26.0
AVERAGE			31	1706	69.2	43.0	43.6	6.4
STD DEV			7.2	92.6	11.8	9.1	9.4	4.9
VARIANCE			52	857[illegible]	139	82	88	24

EXPERIMENTAL GROUP - A (OVERALL)
SAMPLE SIZE - 47

CODE	ORIGIN	SEX	AGE	HGHT	MASS	ARM FLEXION 2 MIN	ARM FLEXION 8 MIN	ARM FLEXION MOVEMEN
:1	AUST	M	23	1880	85.0	95.0	103.0	8.0
:2	AUST	M	22	1810	80.0	109.0	111.0	2.0
:3	AUST	M	22	1810	77.0	100.5	99.0	1.5
:4	AUST	M	28	1759	79.0	103.5	102.0	1.5
:5	AUST	F	21	1645	76.3	112.5	107.5	5.0
:6	AUST	F	30	1708	60.5	107.5	113.0	5.5
:7	AUST	M	27	1880	74.7	101.0	101.0	0.0
:8	AUST	F	26	1568	61.0	103.0	108.5	5.5
:9	AUST	M	28	1798	76.0	109.5	113.5	4.0
:10	AUST	M	29	1836	89.0	97.5	98.0	0.5
:11	AUST	F	26	1696	60.0	96.0	95.0	1.0
:12	AUST	F	21	1630	64.0	108.5	107.5	1.0
:13	ABOR	M	25	1734	61.0	123.0	117.0	6.0
:14	AUST	M	32	1734	67.0	114.0	111.5	2.5
15	AUST	M	25	1683	60.0	102.0	99.0	3.0
16	AUST	M	26	1640	65.5	108.0	114.0	6.0
17	S.AM	F	42	1570	70.0	101.5	102.0	0.5
18	AUST	M	36	1747	100.0	115.0	111.5	3.5
19	ASIA	M	32	1600	50.0	109.0	110.0	1.0
21	AUST	M	45	1938	75.0	91.0	93.5	2.5
22	ENGL	F	35	1683	67.0	95.5	93.5	2.0
26	VIET	F	42	1620	60.0	100.0	95.0	5.0
27	AUST	M	32	1759	89.0	103.0	96.0	7.0
28	AUST	M	27	1734	60.0	93.5	92.0	1.5
29	AUST	M	26	1785	62.0	92.5	102.5	10.0
30	VIET	M	35	1720	74.0	95.0	105.5	10.5
31	AUST	M	30	1816	80.0	106.5	112.0	5.5
32	AUST	M	39	1874	66.0	115.5	121.5	6.0
33	AUST	F	25	1606	69.0	107.0	110.5	3.5
34	ASIA	F	28	1581	60.0	100.0	104.0	4.0
35	ASIA	F	35	1555	49.0	104.0	100.0	4.0
36	AUST	F	29	1606	89.0	113.0	113.0	0.0
37	ASIA	M	45	1700	70.0	104.0	104.0	0.0
38	AUST	M	38	1747	86.0	100.0	109.0	9.0
39	ASIA	M	36	1750	64.0	101.0	109.0	8.0
40	ASIA	M	30	1650	64.0	107.5	121.0	13.5
41	ASIA	M	33	1610	52.0	110.0	132.0	22.0
42	AUST	F	30	1658	60.0	110.0	110.5	0.5
43	POLI	F	26	1747	86.0	132.0	122.0	10.0
44	CHIN	F	25	1680	74.0	106.0	97.5	8.5
45	CHIN	M	28	1606	66.0	105.0	110.0	5.0
46	VIET	F	29	1580	51.0	98.0	104.0	6.0
47	CHIN	F	29	1630	59.0	103.0	101.5	1.5
48	CHIN	M	50	1665	53.0	109.5	107.0	2.5
49	PHIL	M	23	1730	62.0	105.0	111.0	6.0
52	VIET	M	31	1740	86.0	116.5	107.0	9.5
54	AUST	M	51	1700	65.0	108.0	102.5	5.5
INIMUM			21	1555	49.0	91.0	92.0	0.0
AXIMUM			51	1938	100.0	132.0	132.0	22.0
VERAGE			31	1706	69.2	105.3	106.6	4.8
TD DEV			7.2	92.6	11.8	7.8	8.3	4.1
ARIANCE			52	8578	139	62	68	17

XPERIMENTAL GROUP - A (OVERALL)
AMPLE SIZE - 47

ODE	ORIGIN	SEX	AGE	HGHT	MASS	ARM ABDUCTION 2 MIN	ARM ABDUCTION 8 MIN	ARM ABDUCTION MOVEMEN
1	AUST	M	23	1880	85.0	21.0	31.0	10.0
2	AUST	M	22	1810	80.0	36.0	35.0	1.0
3	AUST	M	22	1810	77.0	30.5	29.5	1.0
4	AUST	M	28	1759	79.0	20.0	22.0	2.0
5	AUST	F	21	1645	76.3	25.0	36.5	11.5
6	AUST	F	30	1708	60.5	33.0	26.0	7.0
7	AUST	M	27	1880	74.7	34.5	33.5	1.0
8	AUST	F	26	1568	61.0	18.0	25.5	7.5
9	AUST	M	28	1798	76.0	28.5	29.0	0.5
10	AUST	M	29	1836	89.0	26.0	25.5	0.5
11	AUST	F	26	1696	60.0	27.5	24.5	3.0
12	AUST	F	21	1630	64.0	32.0	25.0	7.0
13	ABOR	M	25	1734	61.0	10.0	13.5	3.5
14	AUST	M	32	1734	67.0	23.0	23.5	0.5
15	AUST	M	25	1683	60.0	37.0	36.5	0.5
16	AUST	M	26	1640	65.5	17.0	19.0	2.0
17	S.AM	F	42	1570	70.0	20.5	15.5	5.0
18	AUST	M	36	1747	100.0	21.0	22.0	1.0
19	ASIA	M	32	1600	50.0	13.5	14.0	0.5
21	AUST	M	45	1938	75.0	23.0	24.0	1.0
22	ENGL	F	35	1683	67.0	25.0	25.0	0.0
26	VIET	F	42	1620	60.0	22.0	15.0	7.0
27	AUST	M	32	1759	89.0	25.0	20.5	4.5
28	AUST	M	27	1734	60.0	28.0	25.5	2.5
29	AUST	M	26	1785	62.0	23.5	21.5	2.0
30	VIET	M	35	1720	74.0	15.5	16.0	0.5
31	AUST	M	30	1816	80.0	20.0	22.0	2.0
32	AUST	M	39	1874	66.0	16.5	17.5	1.0
33	AUST	F	25	1606	69.0	20.0	22.0	2.0
34	ASIA	F	28	1581	60.0	17.0	19.0	2.0
35	ASIA	F	35	1555	49.0	23.0	23.0	0.0
36	AUST	F	29	1606	89.0	25.0	19.0	6.0
37	ASIA	M	45	1700	70.0	19.0	19.0	0.0
38	AUST	M	38	1747	86.0	23.0	24.0	1.0
39	ASIA	M	36	1750	64.0	16.0	20.0	4.0
40	ASIA	M	30	1650	64.0	21.0	21.0	0.0
41	ASIA	M	33	1610	52.0	15.0	24.0	9.0
42	AUST	F	30	1658	60.0	15.0	17.5	2.5
43	POLI	F	26	1747	86.0	22.0	20.0	2.0
44	CHIN	F	25	1680	74.0	15.0	23.0	8.0
45	CHIN	M	28	1606	66.0	30.0	30.0	0.0
46	VIET	F	29	1580	51.0	20.0	22.0	2.0
47	CHIN	F	29	1630	59.0	20.5	17.5	3.0
48	CHIN	M	50	1665	53.0	32.0	28.0	4.0
49	PHIL	M	23	1730	62.0	36.5	36.0	0.5
52	VIET	M	31	1740	86.0	36.5	35.0	1.5
54	AUST	M	51	1700	65.0	30.5	33.5	3.0
INIMUM			21	1555	49.0	10.0	13.5	0.0
AXIMUM			51	1938	100.0	37.0	36.5	11.5
VERAGE			31	1706	69.2	23.6	24.0	2.9
TD DEV			7.2	92.6	11.8	6.8	6.2	2.9
ARIANCE			52	8578	139	46	38	8

EXPERIMENTAL GROUP - A (OVERALL)
SAMPLE SIZE - 47

CODE	ORIGIN	SEX	AGE	HGHT	MASS	ELBOW ANGLE 2 MIN	ELBOW ANGLE 8 MIN	ELBOW ANGLE MOVEMEN
E1	AUST	M	23	1880	85.0	79.0	82.5	3.5
E2	AUST	M	22	1810	80.0	101.0	96.5	4.5
E3	AUST	M	22	1810	77.0	87.0	85.5	1.5
E4	AUST	M	28	1759	79.0	76.5	72.5	4.0
E5	AUST	F	21	1645	76.3	87.5	92.0	4.5
E6	AUST	F	30	1708	60.5	88.0	86.0	2.0
E7	AUST	M	27	1880	74.7	84.5	82.5	2.0
E8	AUST	F	26	1568	61.0	90.5	92.5	2.0
E9	AUST	M	28	1798	76.0	105.5	105.0	0.5
E10	AUST	M	29	1836	89.0	78.5	77.5	1.0
E11	AUST	F	26	1696	60.0	89.5	87.5	2.0
E12	AUST	F	21	1630	64.0	88.5	87.5	1.0
E13	ABOR	M	25	1734	61.0	106.5	110.0	3.5
E14	AUST	M	32	1734	67.0	88.5	88.5	0.0
E15	AUST	M	25	1683	60.0	90.0	89.5	0.5
E16	AUST	M	26	1640	65.5	97.5	94.5	3.0
E17	S.AM	F	42	1570	70.0	82.0	89.0	7.0
E18	AUST	M	36	1747	100.0	103.5	105.0	1.5
E19	ASIA	M	32	1600	50.0	80.0	83.0	3.0
E21	AUST	M	45	1938	75.0	82.0	79.0	3.0
E22	ENGL	F	35	1683	67.0	91.0	86.5	4.5
E26	VIET	F	42	1620	60.0	80.0	91.0	11.0
E27	AUST	M	32	1759	89.0	94.5	94.0	0.5
E28	AUST	M	27	1734	60.0	75.5	79.0	3.5
E29	AUST	M	26	1785	62.0	81.0	78.5	2.5
E30	VIET	M	35	1720	74.0	92.0	99.0	7.0
E31	AUST	M	30	1816	80.0	79.0	84.0	5.0
E32	AUST	M	39	1874	66.0	99.0	106.0	7.0
E33	AUST	F	25	1606	69.0	90.5	96.0	5.5
E34	ASIA	F	28	1581	60.0	94.0	97.0	3.0
E35	ASIA	F	35	1555	49.0	111.0	99.0	12.0
E36	AUST	F	29	1606	89.0	95.0	90.0	5.0
E37	ASIA	M	45	1700	70.0	91.0	88.0	3.0
E38	AUST	M	38	1747	86.0	93.5	98.0	4.5
E39	ASIA	M	36	1750	64.0	82.0	91.5	9.5
E40	ASIA	M	30	1650	64.0	99.0	95.0	4.0
E41	ASIA	M	33	1610	52.0	92.0	98.0	6.0
E42	AUST	F	30	1658	60.0	91.0	83.0	8.0
E43	POLI	F	26	1747	86.0	103.5	98.0	5.5
E44	CHIN	F	25	1680	74.0	82.0	80.0	2.0
E45	CHIN	M	28	1606	66.0	85.0	88.0	3.0
E46	VIET	F	29	1580	51.0	73.0	83.0	10.0
E47	CHIN	F	29	1630	59.0	80.5	80.5	0.0
E48	CHIN	M	50	1665	53.0	104.5	106.5	2.0
E49	PHIL	M	23	1730	62.0	93.5	90.5	3.0
E52	VIET	M	31	1740	86.0	101.5	102.0	0.5
E54	AUST	M	51	1700	65.0	91.5	90.0	1.5
MINIMUM			21	1555	49.0	73.0	72.5	0.0
MAXIMUM			51	1938	100.0	111.0	110.0	12.0
AVERAGE			31	1706	69.2	90.0	90.6	3.8
STD DEV			7.2	92.6	11.8	9.1	8.6	2.9
VARIANCE			52	8578	139	82	74	8

EXPERIMENTAL GROUP - A (OVERALL)
SAMPLE SIZE - 47

CODE	ORIGIN	SEX	AGE	HGHT	MASS	LEFT ULNAR ABDUCTION 2 MIN	8 MIN	MOVEMEN
E1	AUST	M	23	1880	85.0	10.0	9.0	1.0
E2	AUST	M	22	1810	80.0	4.0	6.5	2.5
E3	AUST	M	22	1810	77.0	3.5	2.0	1.5
E4	AUST	M	28	1759	79.0	6.5	6.0	0.5
E5	AUST	F	21	1645	76.3	3.5	2.5	1.0
E6	AUST	F	30	1708	60.5	4.0	5.0	1.0
E7	AUST	M	27	1880	74.7	5.5	12.0	6.5
E8	AUST	F	26	1568	61.0	3.0	5.0	2.0
E9	AUST	M	28	1798	76.0	6.5	4.5	2.0
E10	AUST	M	29	1836	89.0	5.0	6.5	1.5
E11	AUST	F	26	1696	60.0	5.5	7.0	1.5
E12	AUST	F	21	1630	64.0	4.0	2.0	2.0
E13	ABOR	M	25	1734	61.0	0.0	0.5	0.5
E14	AUST	M	32	1734	67.0	0.5	0.0	0.5
E15	AUST	M	25	1683	60.0	5.5	2.5	3.0
E16	AUST	M	26	1640	65.5	18.0	16.5	1.5
E17	S.AM	F	42	1570	70.0	4.0	10.0	6.0
E18	AUST	M	36	1747	100.0	0.0	0.0	0.0
E19	ASIA	M	32	1600	50.0	0.0	0.0	0.0
E21	AUST	M	45	1938	75.0	2.0	2.5	0.5
E22	ENGL	F	35	1683	67.0	19.5	7.5	12.0
E26	VIET	F	42	1620	60.0	5.0	4.0	1.0
E27	AUST	M	32	1759	89.0	8.5	5.5	3.0
E28	AUST	M	27	1734	60.0	1.5	7.0	5.5
E29	AUST	M	26	1785	62.0	5.0	4.5	0.5
E30	VIET	M	35	1720	74.0	0.0	4.0	4.0
E31	AUST	M	30	1816	80.0	10.5	5.0	5.5
E32	AUST	M	39	1874	66.0	3.0	3.0	0.0
E33	AUST	F	25	1606	69.0	1.5	1.5	0.0
E34	ASIA	F	28	1581	60.0	8.0	12.0	4.0
E35	ASIA	F	35	1555	49.0	0.0	0.0	0.0
E36	AUST	F	29	1606	89.0	5.0	10.0	5.0
E37	ASIA	M	45	1700	70.0	0.0	0.0	0.0
E38	AUST	M	38	1747	86.0	4.0	4.0	0.0
E39	ASIA	M	36	1750	64.0	0.0	0.0	0.0
E40	ASIA	M	30	1650	64.0	0.0	2.5	2.5
E41	ASIA	M	33	1610	52.0	0.0	0.0	0.0
E42	AUST	F	30	1658	60.0	1.0	2.0	1.0
E43	POLI	F	26	1747	86.0	2.0	0.0	2.0
E44	CHIN	F	25	1680	74.0	8.0	6.0	2.0
E45	CHIN	M	28	1606	66.0	8.5	9.0	0.5
E46	VIET	F	29	1580	51.0	8.0	6.5	1.5
E47	CHIN	F	29	1630	59.0	6.5	12.0	5.5
E48	CHIN	M	50	1665	53.0	8.0	13.0	5.0
E49	PHIL	M	23	1730	62.0	9.0	7.0	2.0
E52	VIET	M	31	1740	86.0	1.5	1.5	0.0
E54	AUST	M	51	1700	65.0	23.0	12.5	10.5
MINIMUM			21	1555	49.0	0.0	0.0	0.0
MAXIMUM			51	1938	100.0	23.0	16.5	12.0
AVERAGE			31	1706	69.2	5.1	5.1	2.3
STD DEV			7.2	92.6	11.8	5.0	4.2	2.6
VARIANCE			52	8578	139	25	17	7

DATA BASE EXPERIMENTAL GROUP - B

(TABLES)

EXPERIMENTAL GROUP - B (OVERALL)
SAMPLE SIZE - 47

CODE	ORIGIN	SEX	AGE	HGHT	MASS	EYE/FLOOR DISTANCE 2 MIN	8 MIN	MOVEMEN
C1	MAUR	F	25	1632	59.0	1540	1600	60
C2	NEWZ	F	22	1811	60.5	1540	1580	40
C3	AUST	F	20	1630	60.5	1528	1520	8
C4	AUST	F	31	1581	60.5	1112	1118	6
C5	ITAL	F	25	1568	82.0	1680	1580	100
C6	ITAL	F	21	1734	92.0	1558	1640	82
C7	ITAL	F	28	1606	50.0	1228	1248	20
C8	AUST	F	28	1708	91.0	1558	1550	8
C9	ITAL	F	27	1594	70.0	1160	1110	50
C10	AUST	F	34	1683	72.0	1450	1445	5
C11	AUST	F	26	1734	68.0	1400	1448	48
C12	AUST	F	25	1626	55.0	1448	1548	100
C13	AUST	F	28	1575	70.0	1110	1110	0
C14	AUST	F	20	1524	53.8	1145	1170	25
C15	AUST	F	47	1689	61.0	1115	1132	17
C16	AUST	M	25	1778	105.0	1178	1128	50
C17	AUST	F	42	1676	82.3	1132	1145	13
C18	AUST	F	21	1524	54.0	1090	1100	10
C19	PHIL	F	25	1524	45.0	1060	1055	5
C20	AUST	M	20	1755	63.0	1115	1138	23
C21	AUST	F	61	1702	60.2	1182	1168	14
C22	AUST	F	46	1530	45.5	1162	1170	8
C23	AUST	F	24	1680	76.0	1220	1188	32
C24	YUGO	F	20	1607	56.0	1166	1155	11
C25	AUST	F	22	1647	57.0	1173	1182	9
C26	AUST	F	41	1670	64.0	1193	1187	6
C27	ENGL	F	23	1630	47.7	1140	1140	0
C28	GERM	F	26	1721	63.5	1110	1110	0
C29	AUST	F	31	1632	56.0	1164	1180	16
C30	INDI	F	36	1607	52.0	1115	1138	23
C31	AUST	F	21	1747	70.0	1180	1192	12
C32	PHIL	F	25	1441	45.0	1100	1094	6
C33	AUST	F	32	1670	60.5	1160	1172	12
C34	MAUR	F	36	1607	51.0	1102	1175	73
C35	AUST	F	34	1581	64.0	1080	1010	70
C36	AUST	F	29	1683	59.0	1118	1152	34
C37	AUST	F	35	1632	65.0	1132	1140	8
C38	AUST	F	30	1710	68.0	1178	1152	26
C39	AUST	F	28	1658	56.0	1005	1090	85
C40	AUST	F	28	1581	70.0	1150	1153	3
C41	CANA	M	27	1811	73.0	1140	1138	2
C42	MAUR	F	26	1479	50.0	1092	1092	0
C43	AUST	F	28	1632	55.0	1152	1165	13
C44	AUST	F	24	1479	56.0	1112	1080	32
C45	YUGO	F	22	1623	58.0	1155	1181	26
C46	AUST	F	25	1623	60.0	1180	1161	19
C47	AUST	F	24	1619	57.0	1182	1172	10
MINIMUM			20	1441	45.0	1005	1010	0
MAXIMUM			61	1811	105.0	1680	1640	100
AVERAGE			29	1637	62.8	1213	1219	26
STD DEV			8.1	82.8	12.4	159.5	165.8	27.0
VARIANCE			65	6864	153	25433	27492	728

EXPERIMENTAL GROUP - B (OVERALL)
SAMPLE SIZE - 47

CODE	ORIGIN	SEX	AGE	HGHT	MASS	ACROMION/KEYBOARD DISTANCE 2 MIN	8 MIN	MOVEMEN
C1	MAUR	F	25	1632	59.0	275	273	2
C2	NEWZ	F	22	1811	60.5	300	310	10
C3	AUST	F	20	1630	60.5	208	225	17
C4	AUST	F	31	1581	60.5	245	257	12
C5	ITAL	F	25	1568	82.0	239	233	6
C6	ITAL	F	21	1734	92.0	330	332	2
C7	ITAL	F	28	1606	50.0	248	241	7
C8	AUST	F	28	1708	91.0	275	252	23
C9	ITAL	F	27	1594	70.0	283	284	1
C10	AUST	F	34	1683	72.0	274	298	24
C11	AUST	F	26	1734	68.0	311	288	23
C12	AUST	F	25	1626	55.0	283	283	0
C13	AUST	F	28	1575	70.0	238	230	8
C14	AUST	F	20	1524	53.8	225	275	50
C15	AUST	F	47	1689	61.0	273	262	11
C16	AUST	M	25	1778	105.0	290	280	10
C17	AUST	F	42	1676	82.3	265	261	4
C18	AUST	F	21	1524	54.0	218	215	3
C19	PHIL	F	25	1524	45.0	231	240	9
C20	AUST	M	20	1755	63.0	277	283	6
C21	AUST	F	61	1702	60.2	295	284	11
C22	AUST	F	46	1530	45.5	292	292	0
C23	AUST	F	24	1680	76.0	255	254	1
C24	YUGO	F	20	1607	56.0	265	255	10
C25	AUST	F	22	1647	57.0	300	282	18
C26	AUST	F	41	1670	64.0	244	262	18
C27	ENGL	F	23	1630	47.7	257	260	3
C28	GERM	F	26	1721	63.5	269	263	6
C29	AUST	F	31	1632	56.0	292	282	10
C30	INDI	F	36	1607	52.0	245	267	22
C31	AUST	F	21	1747	70.0	304	310	6
C32	PHIL	F	25	1441	45.0	235	229	6
C33	AUST	F	32	1670	60.5	287	263	24
C34	MAUR	F	36	1607	51.0	245	229	16
C35	AUST	F	34	1581	64.0	269	287	18
C36	AUST	F	29	1683	59.0	243	277	34
C37	AUST	F	35	1632	65.0	245	247	2
C38	AUST	F	30	1710	68.0	213	232	19
C39	AUST	F	28	1658	56.0	272	262	10
C40	AUST	F	28	1581	70.0	233	216	17
C41	CANA	M	27	1811	73.0	251	248	3
C42	MAUR	F	26	1479	50.0	201	183	18
C43	AUST	F	28	1632	55.0	248	223	25
C44	AUST	F	24	1479	56.0	219	223	4
C45	YUGO	F	22	1623	58.0	277	283	6
C46	AUST	F	25	1623	60.0	302	282	20
C47	AUST	F	24	1619	57.0	252	254	2
MINIMUM			20	1441	45.0	201	183	0
MAXIMUM			61	1811	105.0	330	332	50
AVERAGE			29	1637	62.8	262	261	12
STD DEV			8.1	82.8	12.4	29.2	28.8	9.9
VARIANCE			65	6864	153	853	828	99

EXPERIMENTAL GROUP - B (OVERALL)
SAMPLE SIZE - 47

CODE	ORIGIN	SEX	AGE	HGHT	MASS	EYE/COPY DISTANCE 2 MIN	8 MIN	MOVEMEN
C1	MAUR	F	25	1632	59.0	740	777	37
C2	NEWZ	F	22	1811	60.5	753	748	5
C3	AUST	F	20	1630	60.5	478	488	10
C4	AUST	F	31	1581	60.5	688	672	16
C5	ITAL	F	25	1568	82.0	758	740	18
C6	ITAL	F	21	1734	92.0	710	721	11
C7	ITAL	F	28	1606	50.0	823	845	22
C8	AUST	F	28	1708	91.0	800	812	12
C9	ITAL	F	27	1594	70.0	728	747	19
C10	AUST	F	34	1683	72.0	708	675	33
C11	AUST	F	26	1734	68.0	778	812	34
C12	AUST	F	25	1626	55.0	766	758	8
C13	AUST	F	28	1575	70.0	827	825	2
C14	AUST	F	20	1524	53.8	665	698	33
C15	AUST	F	47	1689	61.0	658	638	20
C16	AUST	M	25	1778	105.0	738	645	93
C17	AUST	F	42	1676	82.3	661	728	67
C18	AUST	F	21	1524	54.0	772	795	23
C19	PHIL	F	25	1524	45.0	788	776	12
C20	AUST	M	20	1755	63.0	648	687	39
C21	AUST	F	61	1702	60.2	715	708	7
C22	AUST	F	46	1530	45.5	620	652	32
C23	AUST	F	24	1680	76.0	670	756	86
C24	YUGO	F	20	1607	56.0	595	586	9
C25	AUST	F	22	1647	57.0	724	728	4
C26	AUST	F	41	1670	64.0	670	686	16
C27	ENGL	F	23	1630	47.7	682	666	16
C28	GERM	F	26	1721	63.5	622	604	18
C29	AUST	F	31	1632	56.0	564	543	21
C30	INDI	F	36	1607	52.0	723	708	15
C31	AUST	F	21	1747	70.0	724	708	16
C32	PHIL	F	25	1441	45.0	768	786	18
C33	AUST	F	32	1670	60.5	850	876	26
C34	MAUR	F	36	1607	51.0	814	843	29
C35	AUST	F	34	1581	64.0	750	756	6
C36	AUST	F	29	1683	59.0	728	794	66
C37	AUST	F	35	1632	65.0	594	518	76
C38	AUST	F	30	1710	68.0	682	658	24
C39	AUST	F	28	1658	56.0	736	768	32
C40	AUST	F	28	1581	70.0	704	727	23
C41	CANA	M	27	1811	73.0	725	765	40
C42	MAUR	F	26	1479	50.0	692	712	20
C43	AUST	F	28	1632	55.0	588	558	30
C44	AUST	F	24	1479	56.0	706	706	0
C45	YUGO	F	22	1623	58.0	568	618	50
C46	AUST	F	25	1623	60.0	591	603	12
C47	AUST	F	24	1619	57.0	627	627	0
MINIMUM			20	1441	45.0	478	488	0
MAXIMUM			61	1811	105.0	850	876	93
AVERAGE			29	1637	62.8	700	707	26
STD DEV			8.1	82.8	12.4	77.4	87.0	21.3
VARIANCE			65	6864	153	5992	7568	455

EXPERIMENTAL GROUP - B (OVERALL)
SAMPLE SIZE - 47

						TRUNK INCLINATION		
CODE	ORIGIN	SEX	AGE	HGHT	MASS	2 MIN	8 MIN	MOVEMEN
C1	MAUR	F	25	1632	59.0	110.0	106.0	4.0
C2	NEWZ	F	22	1811	60.5	85.5	81.0	4.5
C3	AUST	F	20	1630	60.5	118.0	109.0	9.0
C4	AUST	F	31	1581	60.5	84.5	83.5	1.0
C5	ITAL	F	25	1568	82.0	92.0	110.5	18.5
C6	ITAL	F	21	1734	92.0	99.0	114.0	15.0
C7	ITAL	F	28	1606	50.0	121.0	116.5	4.5
C8	AUST	F	28	1708	91.0	111.0	124.5	13.5
C9	ITAL	F	27	1594	70.0	103.5	99.5	4.0
C10	AUST	F	34	1683	72.0	104.0	112.0	8.0
C11	AUST	F	26	1734	68.0	114.0	110.0	4.0
C12	AUST	F	25	1626	55.0	116.0	107.5	8.5
C13	AUST	F	28	1575	70.0	100.0	101.5	1.5
C14	AUST	F	20	1524	53.8	103.5	114.0	10.5
C15	AUST	F	47	1689	61.0	83.5	86.0	2.5
C16	AUST	M	25	1778	105.0	113.0	101.5	11.5
C17	AUST	F	42	1676	82.3	103.0	103.0	0.0
C18	AUST	F	21	1524	54.0	109.5	108.5	1.0
C19	PHIL	F	25	1524	45.0	105.5	120.0	14.5
C20	AUST	M	20	1755	63.0	113.0	114.5	1.5
C21	AUST	F	61	1702	60.2	125.0	102.5	22.5
C22	AUST	F	46	1530	45.5	106.5	114.5	8.0
C23	AUST	F	24	1680	76.0	114.0	105.0	9.0
C24	YUGO	F	20	1607	56.0	116.0	121.5	5.5
C25	AUST	F	22	1647	57.0	110.0	123.5	13.5
C26	AUST	F	41	1670	64.0	112.5	108.0	4.5
C27	ENGL	F	23	1630	47.7	100.5	97.5	3.0
C28	GERM	F	26	1721	63.5	74.0	75.0	1.0
C29	AUST	F	31	1632	56.0	95.5	91.5	4.0
C30	INDI	F	36	1607	52.0	104.0	108.5	4.5
C31	AUST	F	21	1747	70.0	118.5	105.5	13.0
C32	PHIL	F	25	1441	45.0	104.5	87.5	17.0
C33	AUST	F	32	1670	60.5	113.5	110.5	3.0
C34	MAUR	F	36	1607	51.0	112.5	111.5	1.0
C35	AUST	F	34	1581	64.0	103.0	111.5	8.5
C36	AUST	F	29	1683	59.0	93.5	107.5	14.0
C37	AUST	F	35	1632	65.0	121.5	116.5	5.0
C38	AUST	F	30	1710	68.0	108.5	116.5	8.0
C39	AUST	F	28	1658	56.0	105.5	115.5	10.0
C40	AUST	F	28	1581	70.0	119.5	119.0	0.5
C41	CANA	M	27	1811	73.0	114.0	101.5	12.5
C42	MAUR	F	26	1479	50.0	112.5	115.0	2.5
C43	AUST	F	28	1632	55.0	113.5	117.0	3.5
C44	AUST	F	24	1479	56.0	107.0	109.0	2.0
C45	YUGO	F	22	1623	58.0	118.5	112.5	6.0
C46	AUST	F	25	1623	60.0	107.0	110.0	3.0
C47	AUST	F	24	1619	57.0	116.0	118.5	2.5
MINIMUM			20	1441	45.0	74	75.0	0.0
MAXIMUM			61	1811	105.0	125	124.5	22.5
AVERAGE			29	1637	62.8	107	107.6	6.9
STD DEV			8.1	82.8	12.4	10.7	11.0	5.4
VARIANCE			65	6864	153	114	121	29

EXPERIMENTAL GROUP - B (OVERALL)
SAMPLE SIZE - 47

CODE	ORIGIN	SEX	AGE	HGHT	MASS	HEAD INCLINATION 2 MIN	HEAD INCLINATION 8 MIN	HEAD INCLINATION MOVEMEN
C1	MAUR	F	25	1632	59.0	36.0	33.0	3.0
C2	NEWZ	F	22	1811	60.5	44.0	39.0	5.0
C3	AUST	F	20	1630	60.5	32.0	16.0	16.0
C4	AUST	F	31	1581	60.5	29.0	31.5	2.5
C5	ITAL	F	25	1568	82.0	35.0	17.0	18.0
C6	ITAL	F	21	1734	92.0	35.0	39.5	4.5
C7	ITAL	F	28	1606	50.0	21.0	14.0	7.0
C8	AUST	F	28	1708	91.0	33.0	36.5	3.5
C9	ITAL	F	27	1594	70.0	34.5	31.5	3.0
C10	AUST	F	34	1683	72.0	31.0	29.5	1.5
C11	AUST	F	26	1734	68.0	27.5	17.5	10.0
C12	AUST	F	25	1626	55.0	36.5	22.5	14.0
C13	AUST	F	28	1575	70.0	22.5	14.0	8.5
C14	AUST	F	20	1524	53.8	30.5	21.0	9.5
C15	AUST	F	47	1689	61.0	40.0	43.5	3.5
C16	AUST	M	25	1778	105.0	38.5	53.0	14.5
C17	AUST	F	42	1676	82.3	35.5	31.5	4.0
C18	AUST	F	21	1524	54.0	24.5	25.5	1.0
C19	PHIL	F	25	1524	45.0	30.0	27.5	2.5
C20	AUST	M	20	1755	63.0	27.5	47.0	19.5
C21	AUST	F	61	1702	60.2	26.0	29.5	3.5
C22	AUST	F	46	1530	45.5	34.0	33.5	0.5
C23	AUST	F	24	1680	76.0	22.5	18.5	4.0
C24	YUGO	F	20	1607	56.0	26.5	30.0	3.5
C25	AUST	F	22	1647	57.0	37.5	39.5	2.0
C26	AUST	F	41	1670	64.0	29.0	25.0	4.0
C27	ENGL	F	23	1630	47.7	32.5	36.0	3.5
C28	GERM	F	26	1721	63.5	32.5	28.5	4.0
C29	AUST	F	31	1632	56.0	27.0	18.0	9.0
C30	INDI	F	36	1607	52.0	35.5	57.0	21.5
C31	AUST	F	21	1747	70.0	38.0	33.0	5.0
C32	PHIL	F	25	1441	45.0	25.5	24.5	1.0
C33	AUST	F	32	1670	60.5	51.0	44.5	6.5
C34	MAUR	F	36	1607	51.0	33.0	25.5	7.5
C35	AUST	F	34	1581	64.0	41.5	28.0	13.5
C36	AUST	F	29	1683	59.0	40.0	31.5	8.5
C37	AUST	F	35	1632	65.0	26.5	25.5	1.0
C38	AUST	F	30	1710	68.0	28.0	34.5	6.5
C39	AUST	F	28	1658	56.0	40.5	35.0	5.5
C40	AUST	F	28	1581	70.0	30.5	28.0	2.5
C41	CANA	M	27	1811	73.0	30.0	37.0	7.0
C42	MAUR	F	26	1479	50.0	31.0	26.5	4.5
C43	AUST	F	28	1632	55.0	33.5	33.5	0.0
C44	AUST	F	24	1479	56.0	20.0	18.5	1.5
C45	YUGO	F	22	1623	58.0	28.5	33.5	5.0
C46	AUST	F	25	1623	60.0	36.5	32.5	4.0
C47	AUST	F	24	1619	57.0	32.0	28.0	4.0
MINIMUM			20	1441	45.0	20.0	14.0	0.0
MAXIMUM			61	1811	105.0	51.0	57.0	21.5
AVERAGE			29	1637	62.8	32.2	30.3	6.2
STD DEV			8.1	82.8	12.4	6.2	9.4	5.1
VARIANCE			65	6864	153	38	89	26

EXPERIMENTAL GROUP - B (OVERALL)
SAMPLE SIZE - 47

CODE	ORIGIN	SEX	AGE	HGHT	MASS	ARM FLEXION 2 MIN	8 MIN	MOVEMEN
C1	MAUR	F	25	1632	59.0	99.0	107.5	8.5
C2	NEWZ	F	22	1811	60.5	95.5	96.0	0.5
C3	AUST	F	20	1630	60.5	107.5	96.0	11.5
C4	AUST	F	31	1581	60.5	96.0	100.0	4.0
C5	ITAL	F	25	1568	82.0	102.0	105.5	3.5
C6	ITAL	F	21	1734	92.0	108.0	108.0	0.0
C7	ITAL	F	28	1606	50.0	108.0	111.0	3.0
C8	AUST	F	28	1708	91.0	109.0	110.0	1.0
C9	ITAL	F	27	1594	70.0	109.0	108.5	0.5
C10	AUST	F	34	1683	72.0	108.0	110.5	2.5
C11	AUST	F	26	1734	68.0	104.0	105.5	1.5
C12	AUST	F	25	1626	55.0	106.0	120.5	14.5
C13	AUST	F	28	1575	70.0	100.0	108.5	8.5
C14	AUST	F	20	1524	53.8	106.0	102.0	4.0
C15	AUST	F	47	1689	61.0	93.5	95.5	2.0
C16	AUST	M	25	1778	105.0	111.5	110.0	1.5
C17	AUST	F	42	1676	82.3	102.5	100.5	2.0
C18	AUST	F	21	1524	54.0	113.0	112.5	0.5
C19	PHIL	F	25	1524	45.0	112.5	106.5	6.0
C20	AUST	M	20	1755	63.0	101.0	92.0	9.0
C21	AUST	F	61	1702	60.2	102.5	102.5	0.0
C22	AUST	F	46	1530	45.5	91.0	95.0	4.0
C23	AUST	F	24	1680	76.0	101.0	107.0	6.0
C24	YUGO	F	20	1607	56.0	92.0	96.5	4.5
C25	AUST	F	22	1647	57.0	94.0	98.5	4.5
C26	AUST	F	41	1670	64.0	91.5	91.5	0.0
C27	ENGL	F	23	1630	47.7	105.0	111.0	6.0
C28	GERM	F	26	1721	63.5	123.0	123.5	0.5
C29	AUST	F	31	1632	56.0	98.5	112.5	14.0
C30	INDI	F	36	1607	52.0	111.0	104.0	7.0
C31	AUST	F	21	1747	70.0	106.0	107.0	1.0
C32	PHIL	F	25	1441	45.0	106.5	103.0	3.5
C33	AUST	F	32	1670	60.5	91.5	91.5	0.0
C34	MAUR	F	36	1607	51.0	100.5	103.0	2.5
C35	AUST	F	34	1581	64.0	103.0	98.5	4.5
C36	AUST	F	29	1683	59.0	88.5	92.0	3.5
C37	AUST	F	35	1632	65.0	112.5	111.0	1.5
C38	AUST	F	30	1710	68.0	122.5	95.0	27.5
C39	AUST	F	28	1658	56.0	93.5	94.0	0.5
C40	AUST	F	28	1581	70.0	111.5	107.0	4.5
C41	CANA	M	27	1811	73.0	97.5	111.5	14.0
C42	MAUR	F	26	1479	50.0	98.5	101.0	2.5
C43	AUST	F	28	1632	55.0	111.5	104.0	7.5
C44	AUST	F	24	1479	56.0	110.0	108.5	1.5
C45	YUGO	F	22	1623	58.0	101.5	102.5	1.0
C46	AUST	F	25	1623	60.0	96.5	95.0	1.5
C47	AUST	F	24	1619	57.0	105.0	104.0	1.0
MINIMUM			20	1441	45.0	88.5	91.5	0.0
MAXIMUM			61	1811	105.0	123.0	123.5	27.5
AVERAGE			29	1637	62.8	103.4	103.8	4.4
STD DEV			8.1	82.8	12.4	7.8	7.4	5.1
VARIANCE			65	6864	153	61	54	26

EXPERIMENTAL GROUP - B (OVERALL)
SAMPLE SIZE - 47

						ARM ABDUCTION		
CODE	ORIGIN	SEX	AGE	HGHT	MASS	2 MIN	8 MIN	MOVEMEN
C1	MAUR	F	25	1632	59.0	27.5	20.0	7.5
C2	NEWZ	F	22	1811	60.5	18.5	16.5	2.0
C3	AUST	F	20	1630	60.5	26.0	28.5	2.5
C4	AUST	F	31	1581	60.5	22.5	21.0	1.5
C5	ITAL	F	25	1568	82.0	16.5	20.0	3.5
C6	ITAL	F	21	1734	92.0	29.5	29.0	0.5
C7	ITAL	F	28	1606	50.0	19.5	18.5	1.0
C8	AUST	F	28	1708	91.0	25.0	23.5	1.5
C9	ITAL	F	27	1594	70.0	31.5	24.0	7.5
C10	AUST	F	34	1683	72.0	26.0	25.5	0.5
C11	AUST	F	26	1734	68.0	22.5	23.5	1.0
C12	AUST	F	25	1626	55.0	23.5	28.5	5.0
C13	AUST	F	28	1575	70.0	20.0	21.0	1.0
C14	AUST	F	20	1524	53.8	20.0	26.0	6.0
C15	AUST	F	47	1689	61.0	27.5	22.5	5.0
C16	AUST	M	25	1778	105.0	27.5	37.5	10.0
C17	AUST	F	42	1676	82.3	39.0	30.0	9.0
C18	AUST	F	21	1524	54.0	24.5	32.5	8.0
C19	PHIL	F	25	1524	45.0	26.5	26.0	0.5
C20	AUST	M	20	1755	63.0	30.0	21.5	8.5
C21	AUST	F	61	1702	60.2	24.0	24.0	0.0
C22	AUST	F	46	1530	45.5	19.5	25.5	6.0
C23	AUST	F	24	1680	76.0	23.5	27.0	3.5
C24	YUGO	F	20	1607	56.0	21.5	25.5	4.0
C25	AUST	F	22	1647	57.0	22.5	24.5	2.0
C26	AUST	F	41	1670	64.0	28.0	31.5	3.5
C27	ENGL	F	23	1630	47.7	33.5	38.5	5.0
C28	GERM	F	26	1721	63.5	37.5	44.0	6.5
C29	AUST	F	31	1632	56.0	27.5	28.5	1.0
C30	INDI	F	36	1607	52.0	34.5	29.0	5.5
C31	AUST	F	21	1747	70.0	24.0	34.5	10.5
C32	PHIL	F	25	1441	45.0	40.5	31.5	9.0
C33	AUST	F	32	1670	60.5	27.5	28.0	0.5
C34	MAUR	F	36	1607	51.0	29.5	25.5	4.0
C35	AUST	F	34	1581	64.0	20.0	20.5	0.5
C36	AUST	F	29	1683	59.0	20.5	22.5	2.0
C37	AUST	F	35	1632	65.0	18.0	19.0	1.0
C38	AUST	F	30	1710	68.0	31.5	23.0	8.5
C39	AUST	F	28	1658	56.0	23.0	19.0	4.0
C40	AUST	F	28	1581	70.0	22.0	24.5	2.5
C41	CANA	M	27	1811	73.0	21.0	27.5	6.5
C42	MAUR	F	26	1479	50.0	27.0	22.5	4.5
C43	AUST	F	28	1632	55.0	19.0	23.0	4.0
C44	AUST	F	24	1479	56.0	16.5	17.5	1.0
C45	YUGO	F	22	1623	58.0	18.5	13.0	5.5
C46	AUST	F	25	1623	60.0	17.0	19.0	2.0
C47	AUST	F	24	1619	57.0	18.5	13.0	5.5
MINIMUM			20	1441	45.0	16.5	13.0	0.0
MAXIMUM			61	1811	105.0	40.5	44.0	10.5
AVERAGE			29	1637	62.8	24.9	25.0	4.1
STD DEV			8.1	82.8	12.4	5.8	6.1	2.9
VARIANCE			65	6864	153	34	37	9

EXPERIMENTAL GROUP - B (OVERALL)
SAMPLE SIZE - 47

CODE	ORIGIN	SEX	AGE	HGHT	MASS	ELBOW ANGLE 2 MIN	8 MIN	MOVEMEN
C1	MAUR	F	25	1632	59.0	91.5	100.5	9.0
C2	NEWZ	F	22	1811	60.5	98.5	96.5	2.0
C3	AUST	F	20	1630	60.5	85.0	85.0	0.0
C4	AUST	F	31	1581	60.5	85.0	79.5	5.5
C5	ITAL	F	25	1568	82.0	98.0	92.0	6.0
C6	ITAL	F	21	1734	92.0	103.5	111.0	7.5
C7	ITAL	F	28	1606	50.0	77.5	84.0	6.5
C8	AUST	F	28	1708	91.0	101.5	99.0	2.5
C9	ITAL	F	27	1594	70.0	93.0	91.5	1.5
C10	AUST	F	34	1683	72.0	90.0	90.0	0.0
C11	AUST	F	26	1734	68.0	111.0	107.5	3.5
C12	AUST	F	25	1626	55.0	101.0	109.5	8.5
C13	AUST	F	28	1575	70.0	86.5	83.5	3.0
C14	AUST	F	20	1524	53.8	89.0	89.5	0.5
C15	AUST	F	47	1689	61.0	95.5	94.0	1.5
C16	AUST	M	25	1778	105.0	105.0	116.0	11.0
C17	AUST	F	42	1676	82.3	97.5	91.5	6.0
C18	AUST	F	21	1524	54.0	105.0	111.5	6.5
C19	PHIL	F	25	1524	45.0	109.5	86.5	23.0
C20	AUST	M	20	1755	63.0	110.0	82.5	27.5
C21	AUST	F	61	1702	60.2	108.0	105.5	2.5
C22	AUST	F	46	1530	45.5	95.5	105.0	9.5
C23	AUST	F	24	1680	76.0	107.5	106.0	1.5
C24	YUGO	F	20	1607	56.0	86.5	95.0	8.5
C25	AUST	F	22	1647	57.0	88.5	88.5	0.0
C26	AUST	F	41	1670	64.0	78.5	87.5	9.0
C27	ENGL	F	23	1630	47.7	90.0	96.0	6.0
C28	GERM	F	26	1721	63.5	116.5	121.5	5.0
C29	AUST	F	31	1632	56.0	104.5	105.0	0.5
C30	INDI	F	36	1607	52.0	120.5	120.5	0.0
C31	AUST	F	21	1747	70.0	92.5	111.0	18.5
C32	PHIL	F	25	1441	45.0	113.5	81.5	32.0
C33	AUST	F	32	1670	60.5	81.5	82.0	0.5
C34	MAUR	F	36	1607	51.0	89.0	108.0	19.0
C35	AUST	F	34	1581	64.0	99.0	99.5	0.5
C36	AUST	F	29	1683	59.0	87.0	86.5	0.5
C37	AUST	F	35	1632	65.0	115.0	104.0	11.0
C38	AUST	F	30	1710	68.0	109.0	92.5	16.5
C39	AUST	F	28	1658	56.0	88.0	87.5	0.5
C40	AUST	F	28	1581	70.0	96.5	93.5	3.0
C41	CANA	M	27	1811	73.0	93.5	101.0	7.5
C42	MAUR	F	26	1479	50.0	75.0	83.5	8.5
C43	AUST	F	28	1632	55.0	100.0	90.0	10.0
C44	AUST	F	24	1479	56.0	89.5	99.0	9.5
C45	YUGO	F	22	1623	58.0	96.5	109.0	12.5
C46	AUST	F	25	1623	60.0	100.0	97.0	3.0
C47	AUST	F	24	1619	57.0	108.0	103.5	4.5
MINIMUM			20	1441	45.0	75.0	79.5	0.0
MAXIMUM			61	1811	105.0	120.5	121.5	32.0
AVERAGE			29	1637	62.8	97.1	97.0	7.1
STD DEV			8.1	82.8	12.4	10.7	10.8	7.2
VARIANCE			65	6864	153	115	117	52

EXPERIMENTAL GROUP - B (OVERALL)
SAMPLE SIZE - 47

CODE	ORIGIN	SEX	AGE	HGHT	MASS	LEFT ULNAR ABDUCTION 2 MIN	8 MIN	MOVEMEN
C1	MAUR	F	25	1632	59.0	12.5	18.0	5.5
C2	NEWZ	F	22	1811	60.5	9.0	6.5	2.5
C3	AUST	F	20	1630	60.5	16.0	17.0	1.0
C4	AUST	F	31	1581	60.5	19.5	13.5	6.0
C5	ITAL	F	25	1568	82.0	8.0	9.0	1.0
C6	ITAL	F	21	1734	92.0	12.5	15.5	3.0
C7	ITAL	F	28	1606	50.0	12.0	8.5	3.5
C8	AUST	F	28	1708	91.0	9.5	11.0	1.5
C9	ITAL	F	27	1594	70.0	15.5	16.5	1.0
C10	AUST	F	34	1683	72.0	9.5	10.5	1.0
C11	AUST	F	26	1734	68.0	12.0	17.5	5.5
C12	AUST	F	25	1626	55.0	14.0	17.5	3.5
C13	AUST	F	28	1575	70.0	5.0	4.5	0.5
C14	AUST	F	20	1524	53.8	0.0	5.0	5.0
C15	AUST	F	47	1689	61.0	7.5	5.0	2.5
C16	AUST	M	25	1778	105.0	11.0	11.5	0.5
C17	AUST	F	42	1676	82.3	14.5	10.0	4.5
C18	AUST	F	21	1524	54.0	8.5	11.0	2.5
C19	PHIL	F	25	1524	45.0	0.0	0.0	0.0
C20	AUST	M	20	1755	63.0	10.0	6.5	3.5
C21	AUST	F	61	1702	60.2	2.5	2.5	0.0
C22	AUST	F	46	1530	45.5	32.0	23.5	8.5
C23	AUST	F	24	1680	76.0	8.5	3.5	5.0
C24	YUGO	F	20	1607	56.0	15.5	16.0	0.5
C25	AUST	F	22	1647	57.0	8.0	8.0	0.0
C26	AUST	F	41	1670	64.0	8.0	10.5	2.5
C27	ENGL	F	23	1630	47.7	13.5	7.5	6.0
C28	GERM	F	26	1721	63.5	13.5	16.0	2.5
C29	AUST	F	31	1632	56.0	11.5	6.5	5.0
C30	INDI	F	36	1607	52.0	8.0	18.5	10.5
C31	AUST	F	21	1747	70.0	14.5	19.5	5.0
C32	PHIL	F	25	1441	45.0	9.5	12.0	2.5
C33	AUST	F	32	1670	60.5	5.0	8.0	3.0
C34	MAUR	F	36	1607	51.0	12.5	10.0	2.5
C35	AUST	F	34	1581	64.0	8.0	11.0	3.0
C36	AUST	F	29	1683	59.0	16.0	19.5	3.5
C37	AUST	F	35	1632	65.0	16.5	18.0	1.5
C38	AUST	F	30	1710	68.0	13.5	8.5	5.0
C39	AUST	F	28	1658	56.0	11.5	11.5	0.0
C40	AUST	F	28	1581	70.0	12.0	14.0	2.0
C41	CANA	M	27	1811	73.0	5.0	2.5	2.5
C42	MAUR	F	26	1479	50.0	0.0	9.5	9.5
C43	AUST	F	28	1632	55.0	6.0	18.5	12.5
C44	AUST	F	24	1479	56.0	15.5	13.5	2.0
C45	YUGO	F	22	1623	58.0	5.5	7.0	1.5
C46	AUST	F	25	1623	60.0	5.0	9.0	4.0
C47	AUST	F	24	1619	57.0	5.0	5.0	0.0
MINIMUM			20	1441	45.0	0.0	0.0	0.0
MAXIMUM			61	1811	105.0	32.0	23.5	12.5
AVERAGE			29	1637	62.8	10.4	11.1	3.3
STD DEV			8.1	82.8	12.4	5.6	5.4	2.8
VARIANCE			65	6864	153	31	29	8

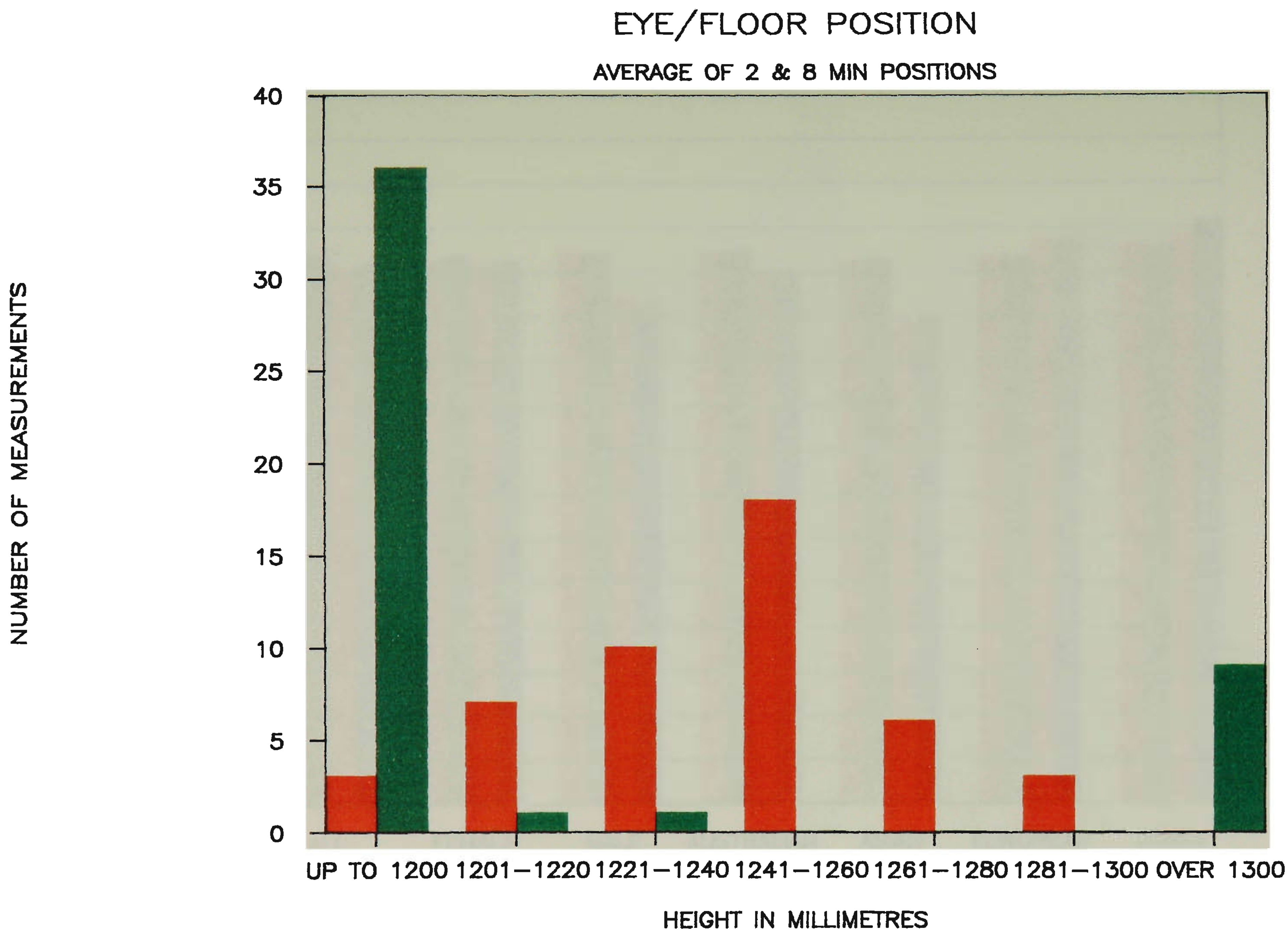
APPENDICES

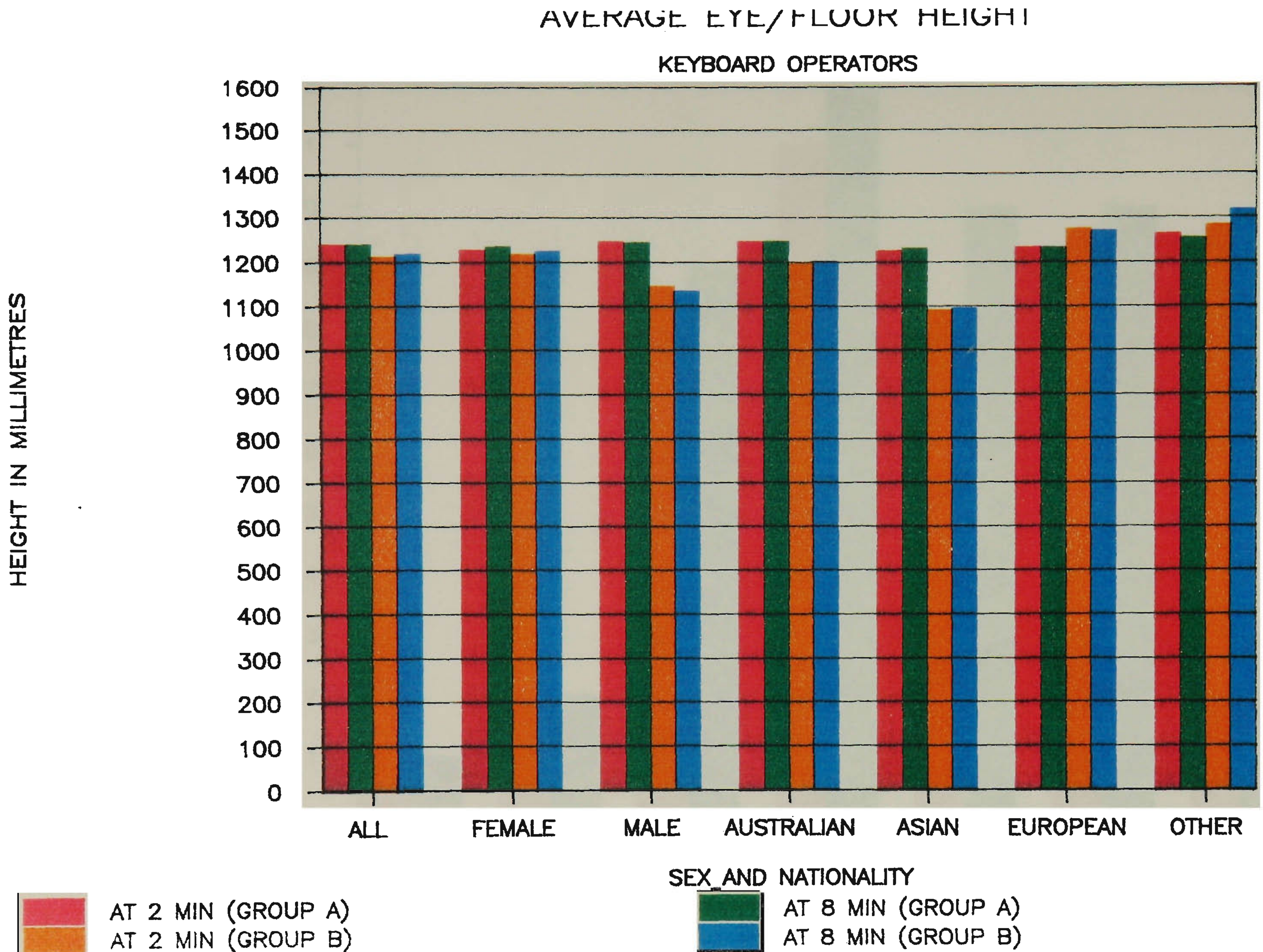
APPENDIX B - Separate Histogram Summaries for Experimental Groups A and B, showing the results for:

- eye to floor measurements;
- shoulder acromion to key board home heights;
- eye to copy distances;
- trunk inclinations;
- head inclinations;
- upper arm flexions from the shoulder joints;
- arm abductions from the body sides;
- elbow angles;
- left wrist-joint ulnar abductions.

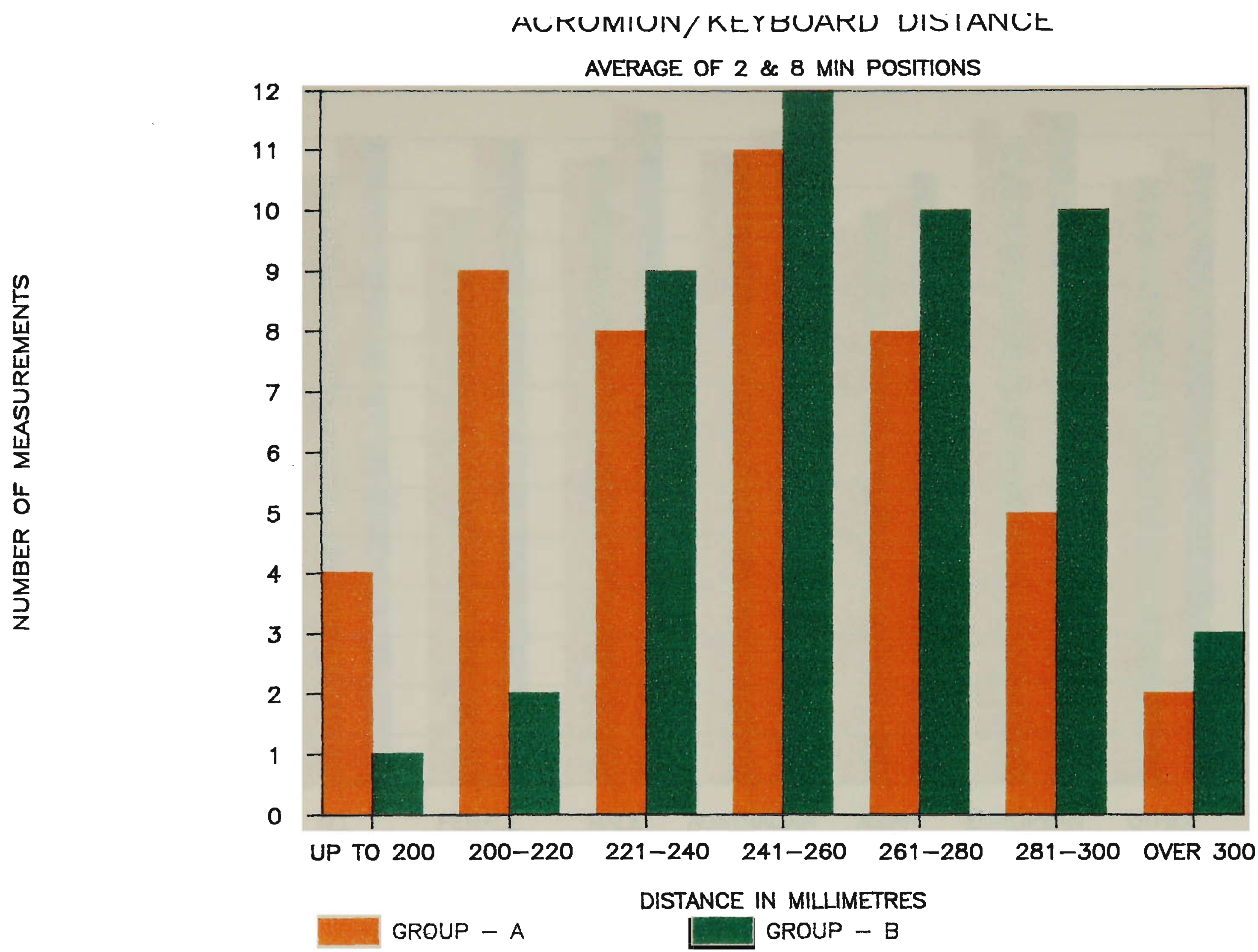
AVERAGE POSITIONS

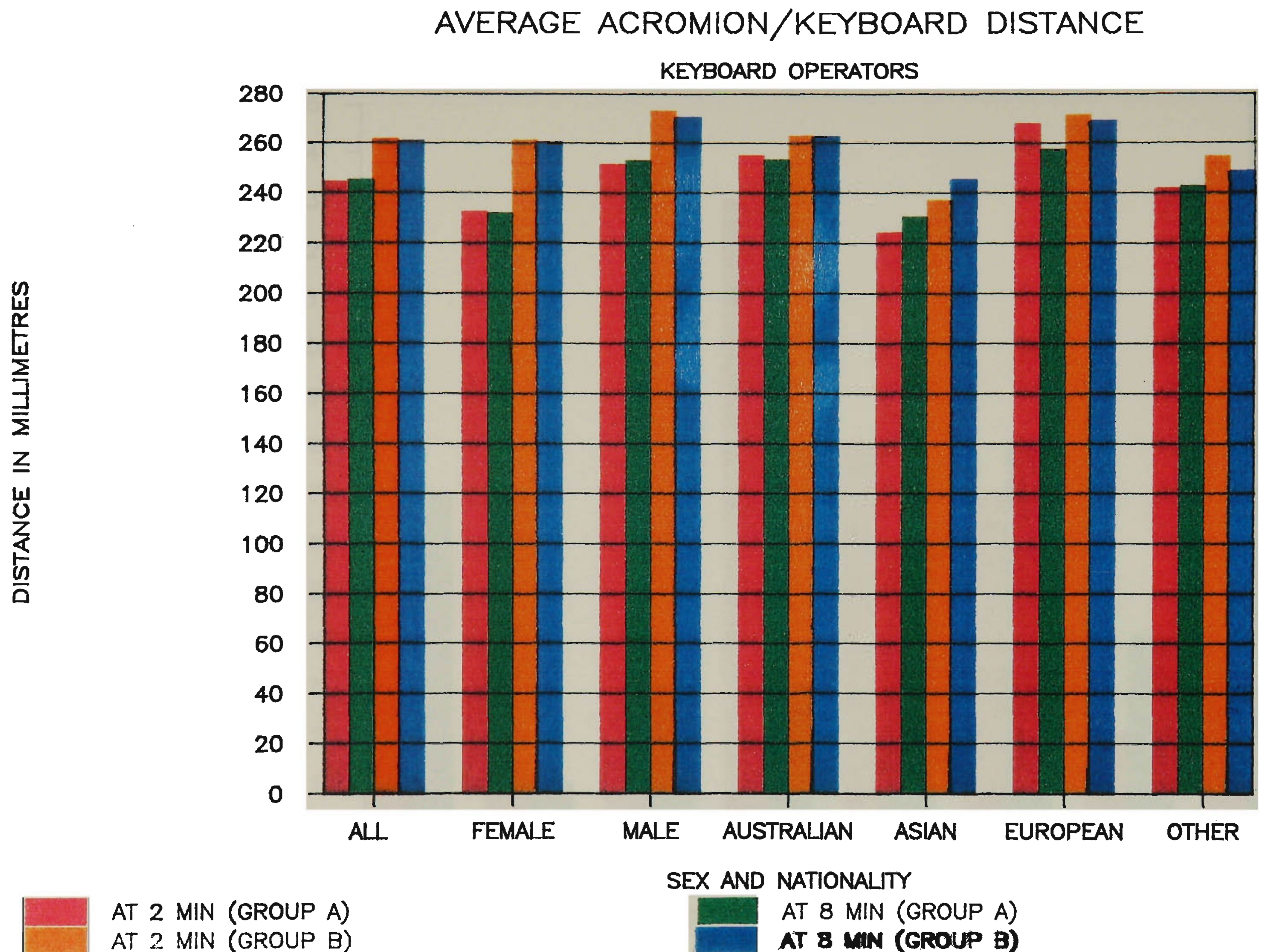
(GRAPHS)


EYE/FLOOR POSITION
AVERAGE OF 2 & 8 MIN POSITIONS
NUMBER OF MEASUREMENTS
0
5
10
15
20
25
30
35
40
UP TO 1200
1201–1220
1221–1240
1241–1260
1261–1280
1281–1300
OVER 1300
HEIGHT IN MILLIMETRES

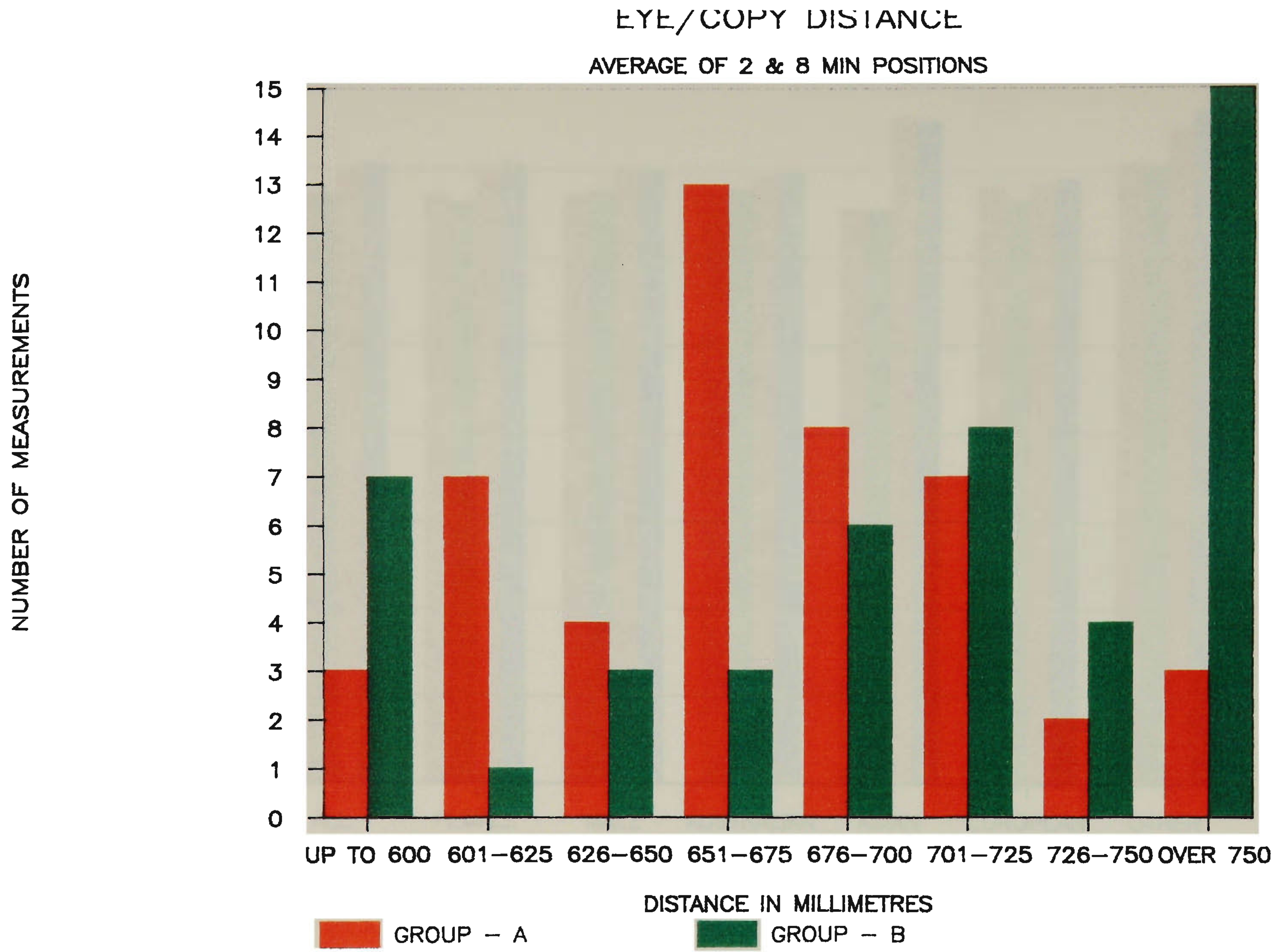


AVERAGE EYE/FLOOR HEIGHT
KEYBOARD OPERATORS
HEIGHT IN MILLIMETRES
1600
1500
1400
1300
1200
1100
1000
900
800
700
600
500
400
300
200
100
0
ALL
FEMALE
MALE
AUSTRALIAN
ASIAN
EUROPEAN
OTHER
SEX AND NATIONALITY
AT 2 MIN (GROUP A)
AT 2 MIN (GROUP B)
AT 8 MIN (GROUP A)
AT 8 MIN (GROUP B)


ACROMION/KEYBOARD DISTANCE
AVERAGE OF 2 & 8 MIN POSITIONS
NUMBER OF MEASUREMENTS
0
1
2
3
4
5
6
7
8
9
10
11
12
UP TO 200
200–220
221–240
241–260
261–280
281–300
OVER 300
DISTANCE IN MILLIMETRES
GROUP – A
GROUP – B



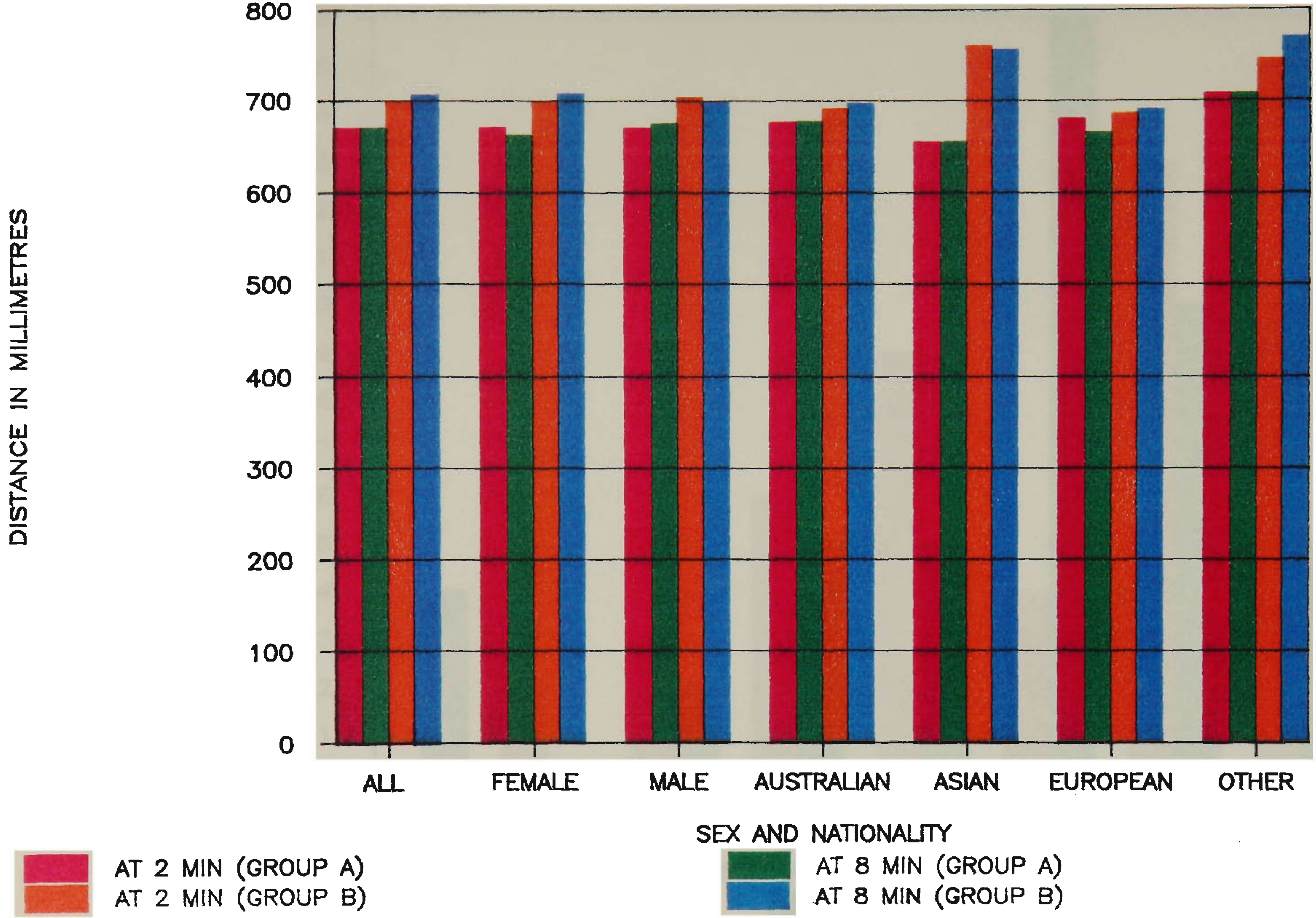
AVERAGE ACROMION/KEYBOARD DISTANCE
KEYBOARD OPERATORS
DISTANCE IN MILLIMETRES
280
260
240
220
200
180
160
140
120
100
80
60
40
20
0
ALL
FEMALE
MALE
AUSTRALIAN
ASIAN
EUROPEAN
OTHER
SEX AND NATIONALITY
AT 2 MIN (GROUP A)
AT 2 MIN (GROUP B)
AT 8 MIN (GROUP A)
AT 8 MIN (GROUP B)

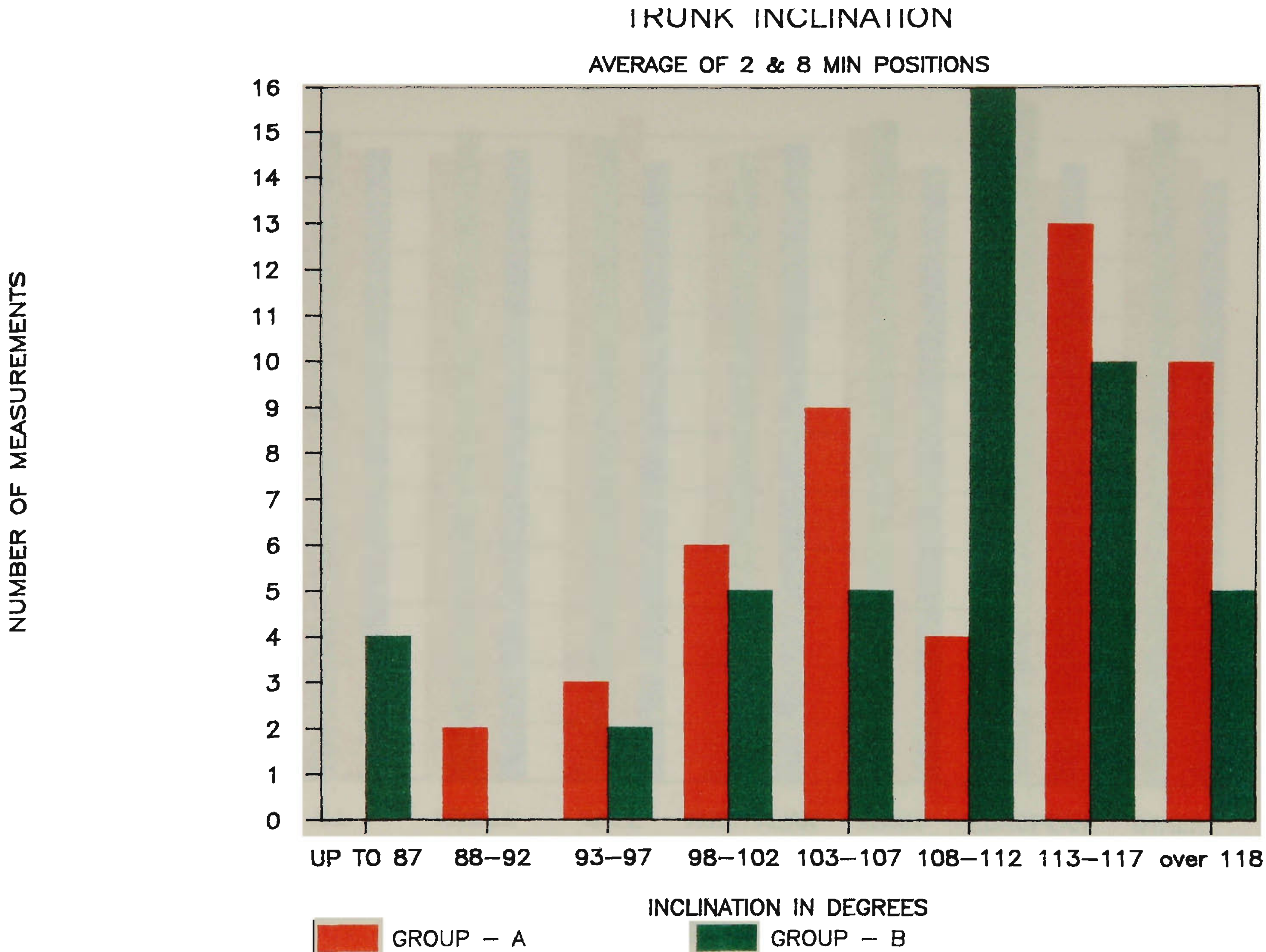


EYE/COPY DISTANCE
AVERAGE OF 2 & 8 MIN POSITIONS
NUMBER OF MEASUREMENTS
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
UP TO 600
601–625
626–650
651–675
676–700
701–725
726–750
OVER 750
DISTANCE IN MILLIMETRES
GROUP – A
GROUP – B

AVERAGE EYE/COPY DISTANCE

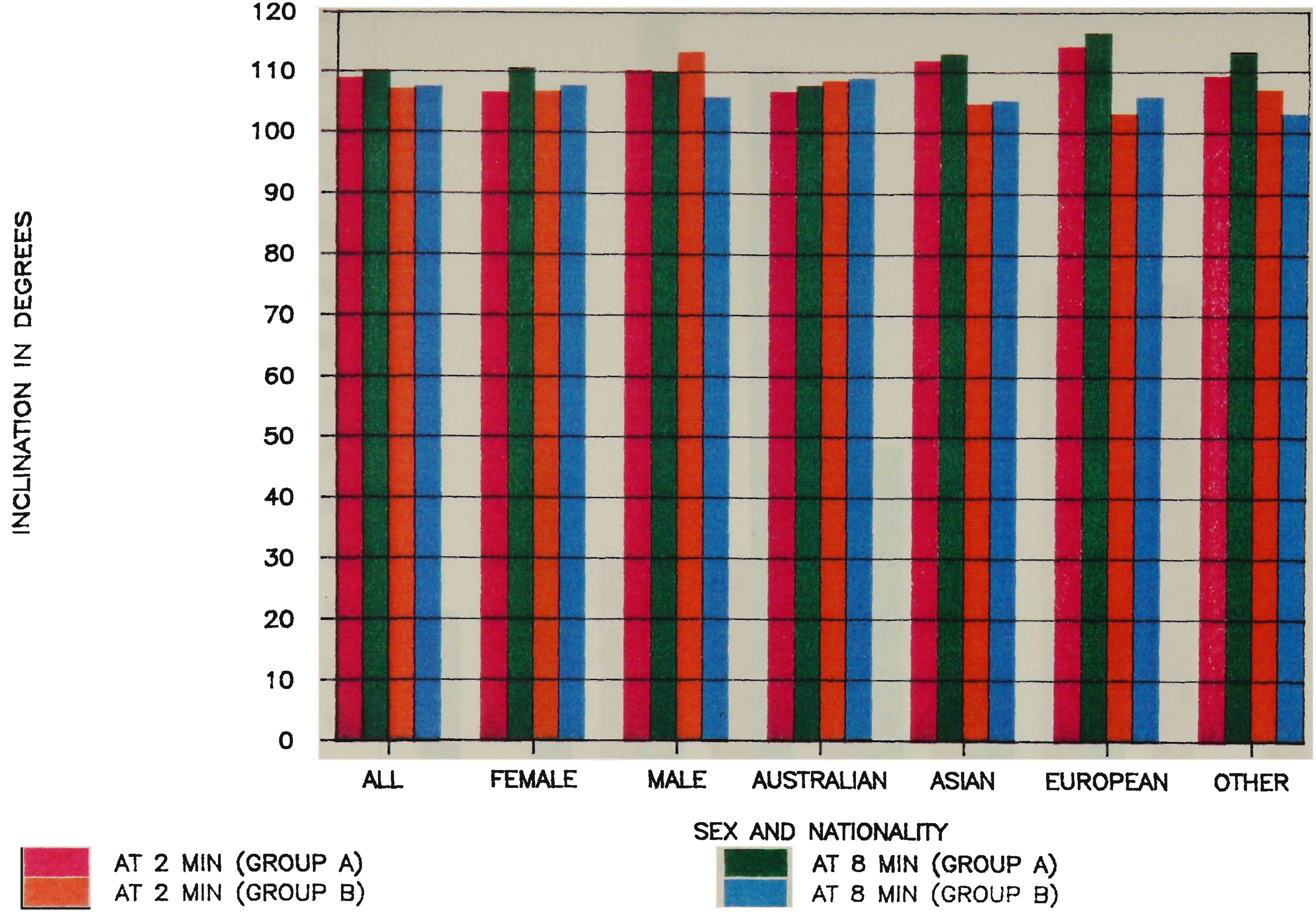
KEYBOARD OPERATORS




TRUNK INCLINATION
AVERAGE OF 2 & 8 MIN POSITIONS
NUMBER OF MEASUREMENTS
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
UP TO 87
88-92
93-97
98-102
103-107
108-112
113-117
over 118
INCLINATION IN DEGREES
GROUP - A
GROUP - B

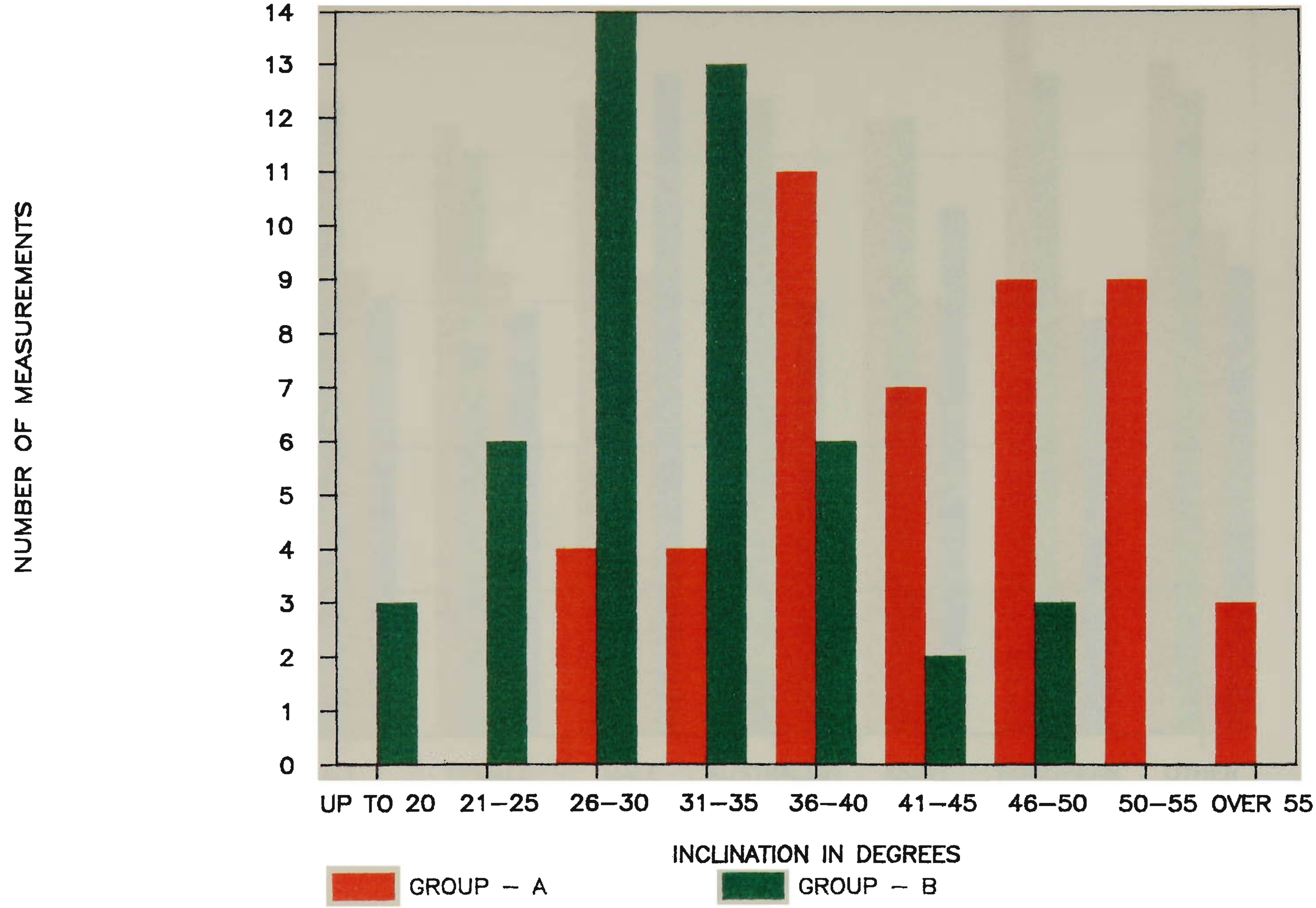
AVERAGE TRUNK INCLINATION

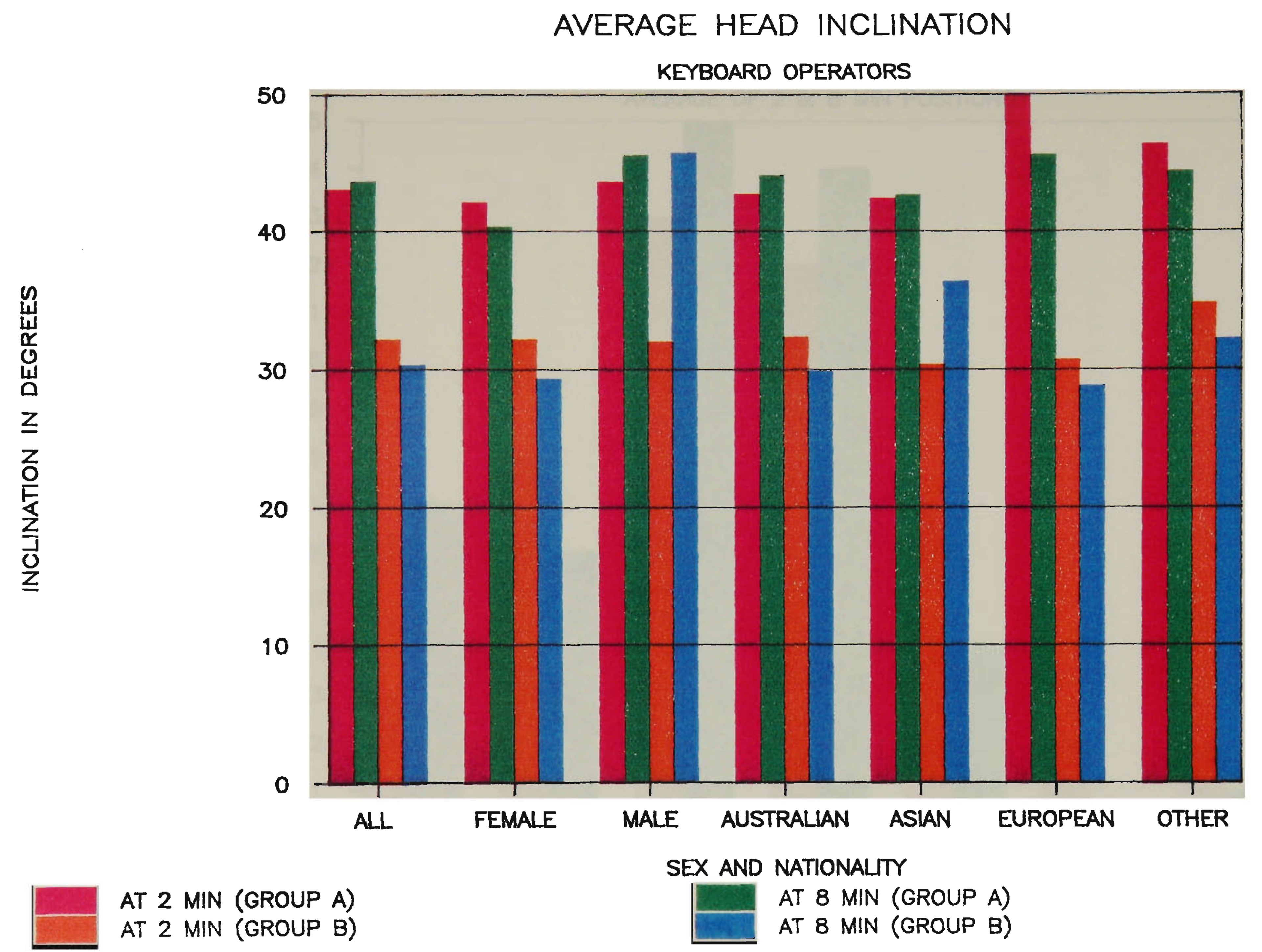
KEYBOARD OPERATORS



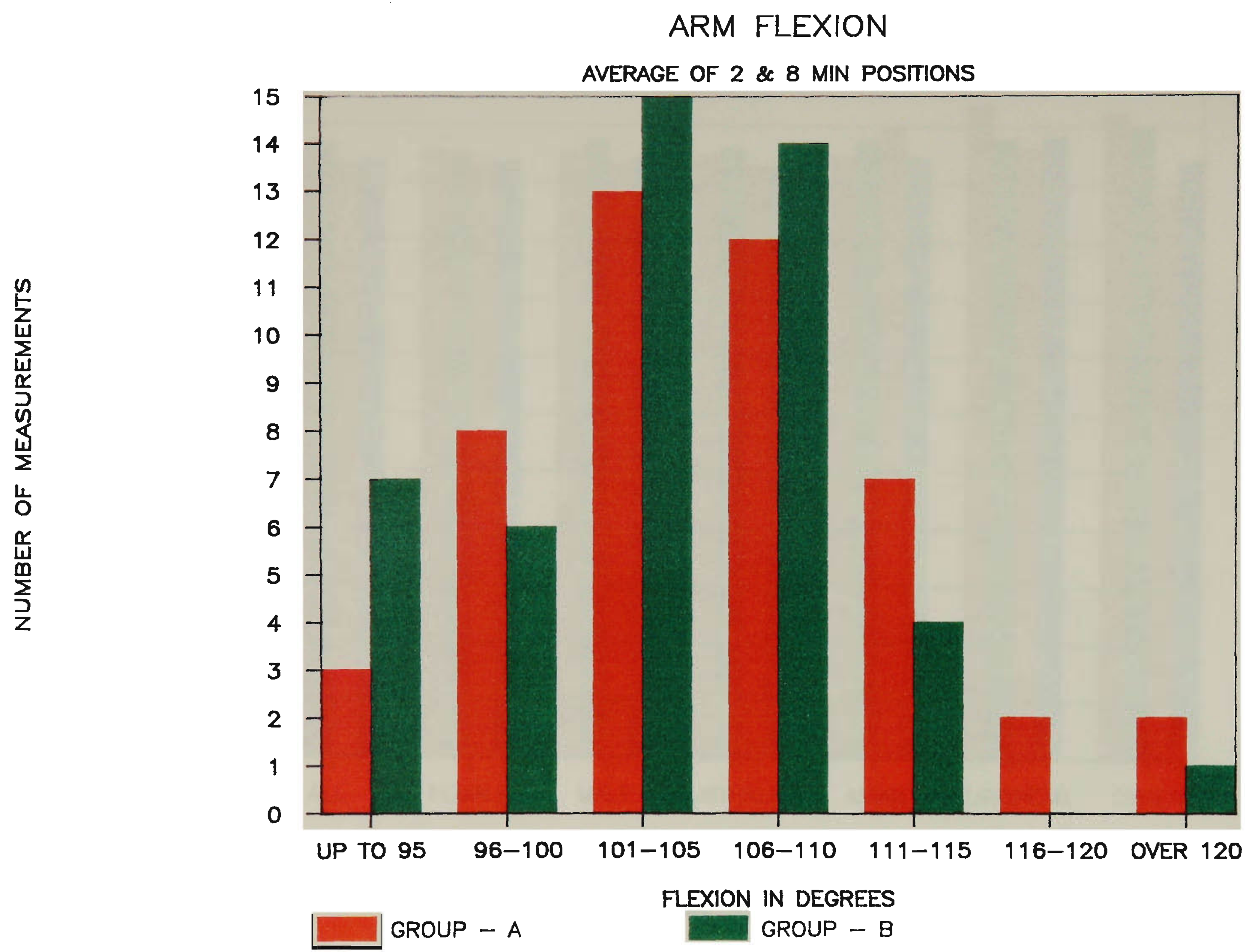
HEAD INCLINATION

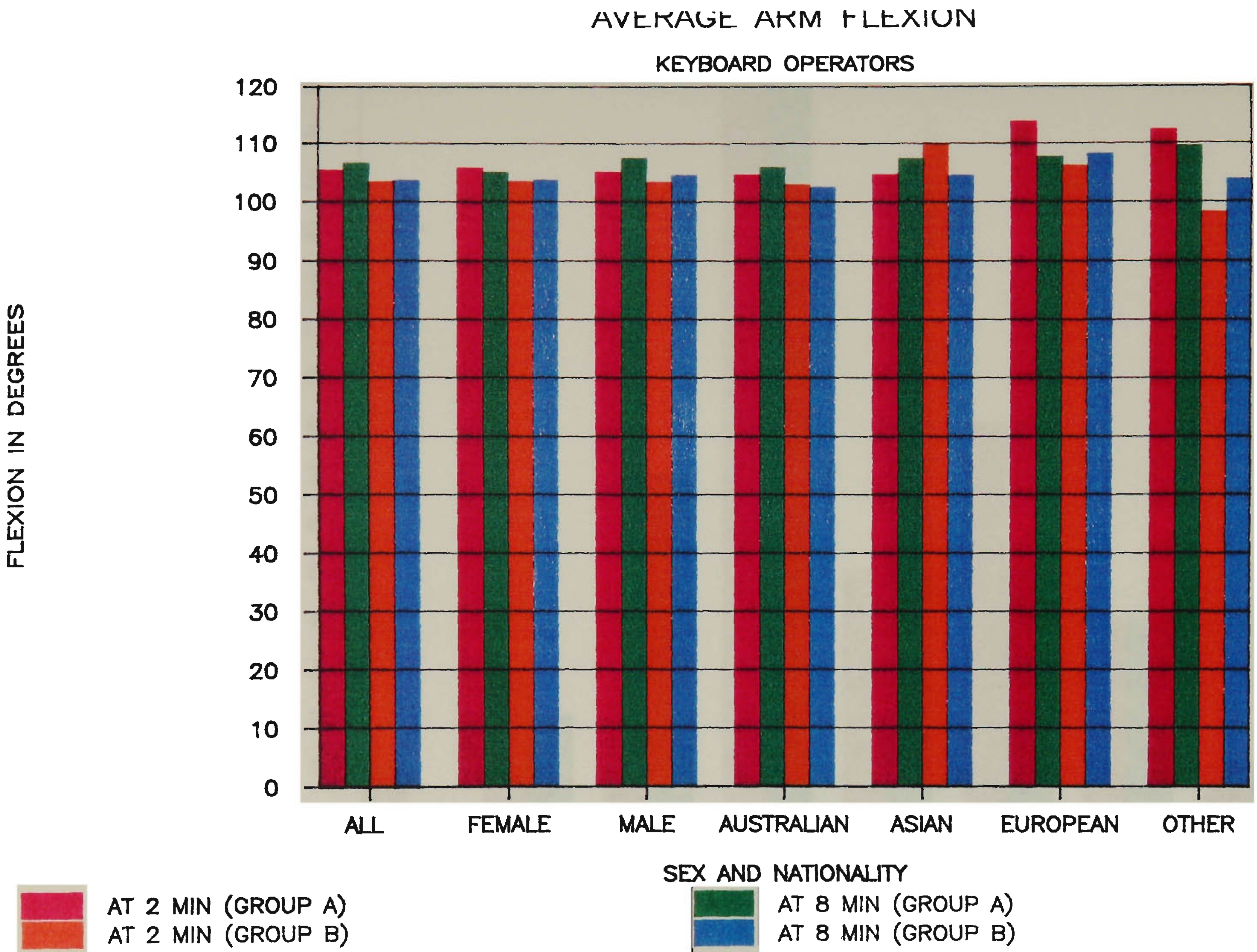
AVERAGE OF 2 & 8 MIN POSITIONS

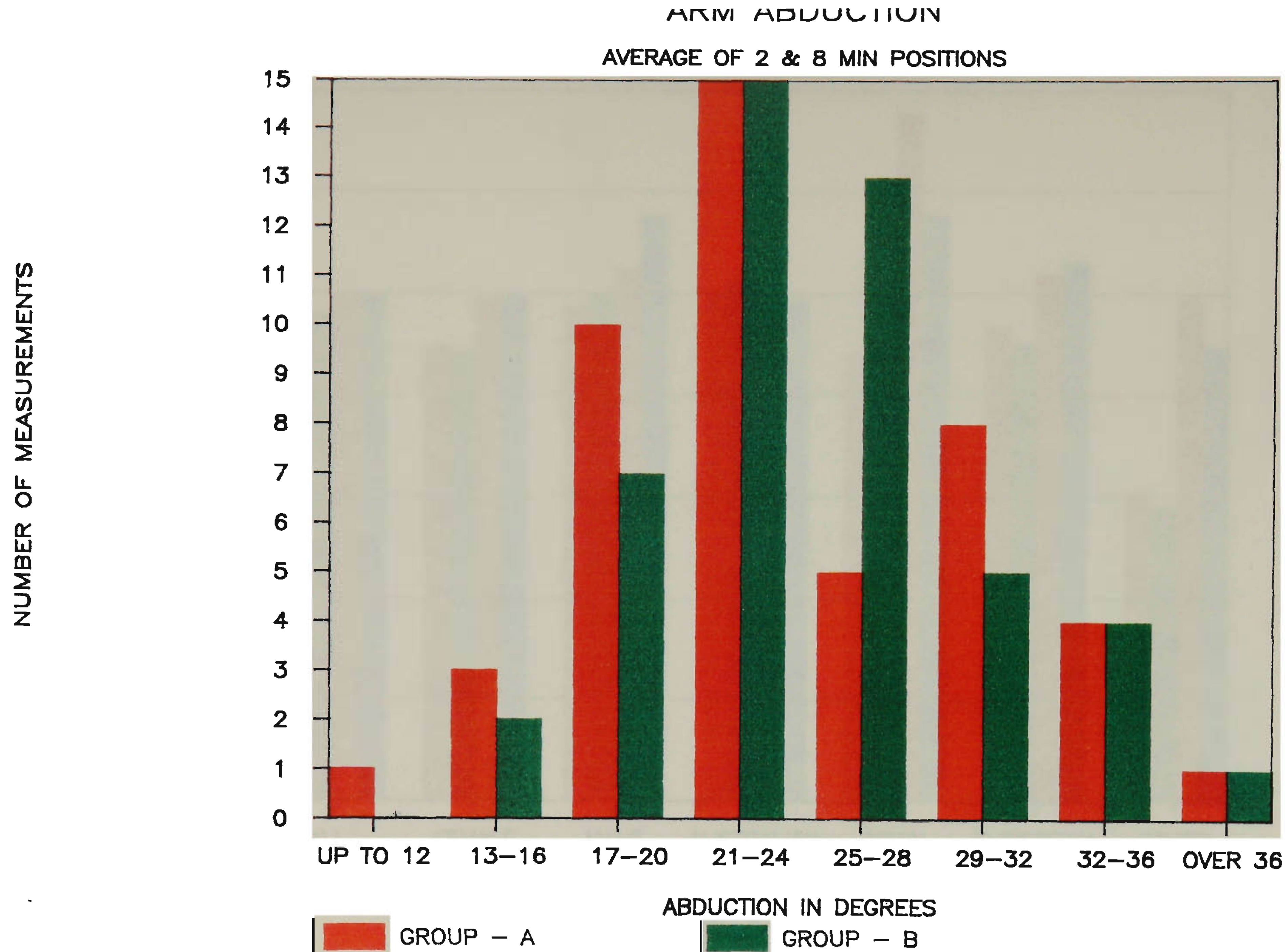




AVERAGE HEAD INCLINATION
KEYBOARD OPERATORS
INCLINATION IN DEGREES
50
40
30
20
10
0
ALL
FEMALE
MALE
AUSTRALIAN
ASIAN
EUROPEAN
OTHER
SEX AND NATIONALITY
AT 2 MIN (GROUP A)
AT 2 MIN (GROUP B)
AT 8 MIN (GROUP A)
AT 8 MIN (GROUP B)

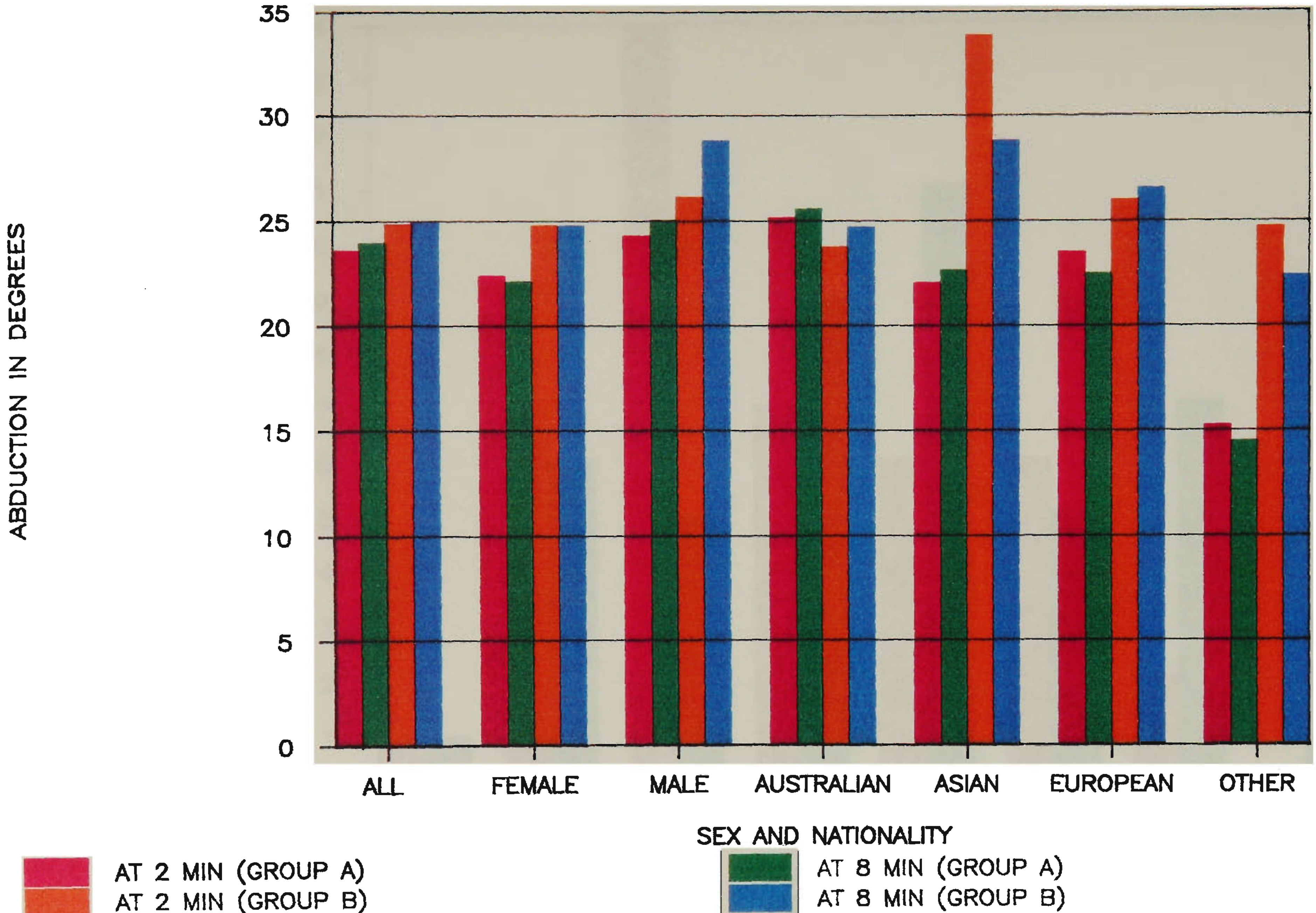

ARM FLEXION
AVERAGE OF 2 & 8 MIN POSITIONS
NUMBER OF MEASUREMENTS
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
UP TO 95
96–100
101–105
106–110
111–115
116–120
OVER 120
FLEXION IN DEGREES
GROUP – A
GROUP – B

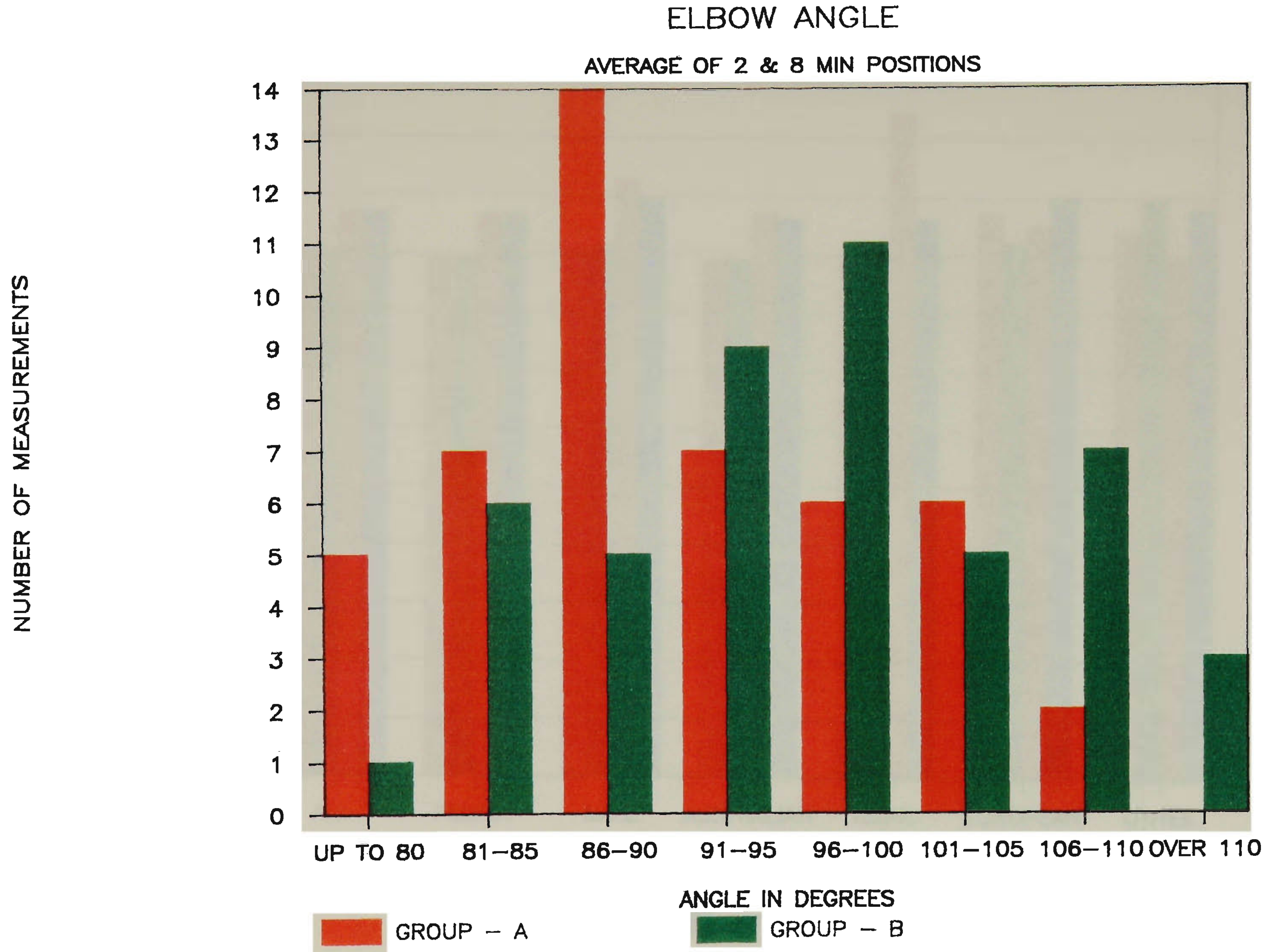

AVERAGE ARM FLEXION
KEYBOARD OPERATORS
FLEXION IN DEGREES
120
110
100
90
80
70
60
50
40
30
20
10
0
ALL
FEMALE
MALE
AUSTRALIAN
ASIAN
EUROPEAN
OTHER
SEX AND NATIONALITY
AT 2 MIN (GROUP A)
AT 2 MIN (GROUP B)
AT 8 MIN (GROUP A)
AT 8 MIN (GROUP B)

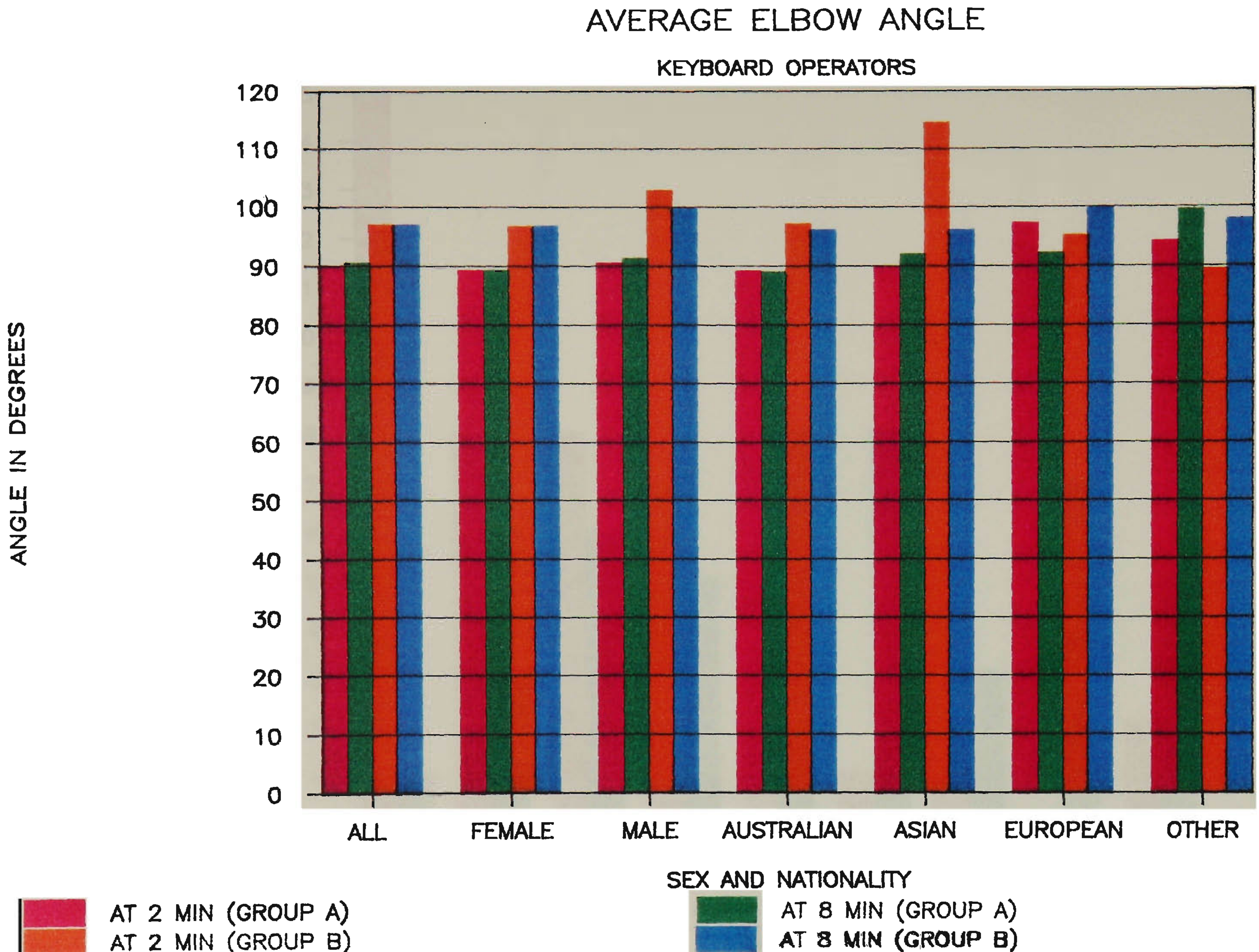

ARM ABDUCTION
AVERAGE OF 2 & 8 MIN POSITIONS
NUMBER OF MEASUREMENTS
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
UP TO 12
13–16
17–20
21–24
25–28
29–32
32–36
OVER 36
ABDUCTION IN DEGREES
GROUP – A
GROUP – B

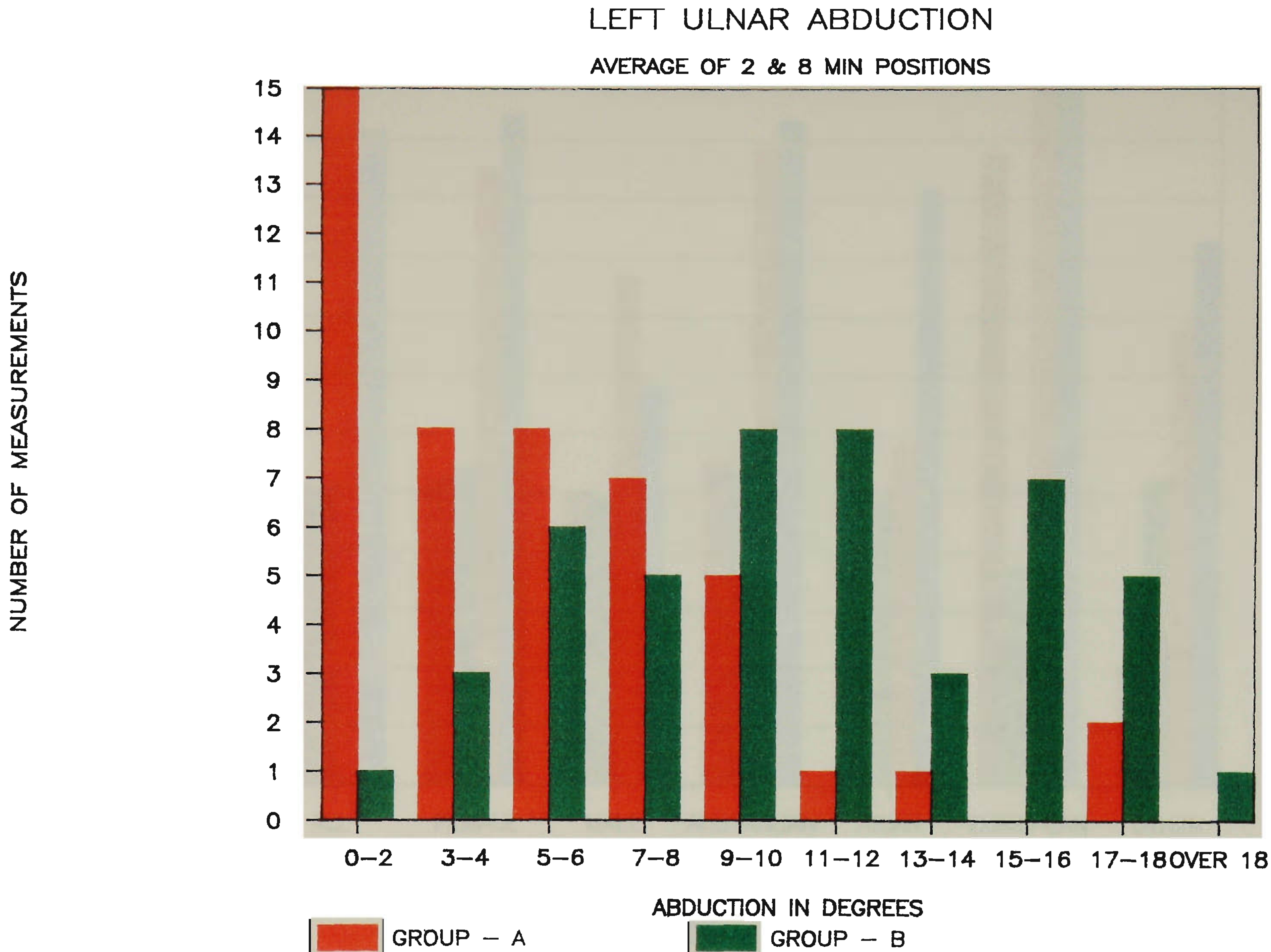
AVERAGE ARM ABDUCTION

KEYBOARD OPERATORS

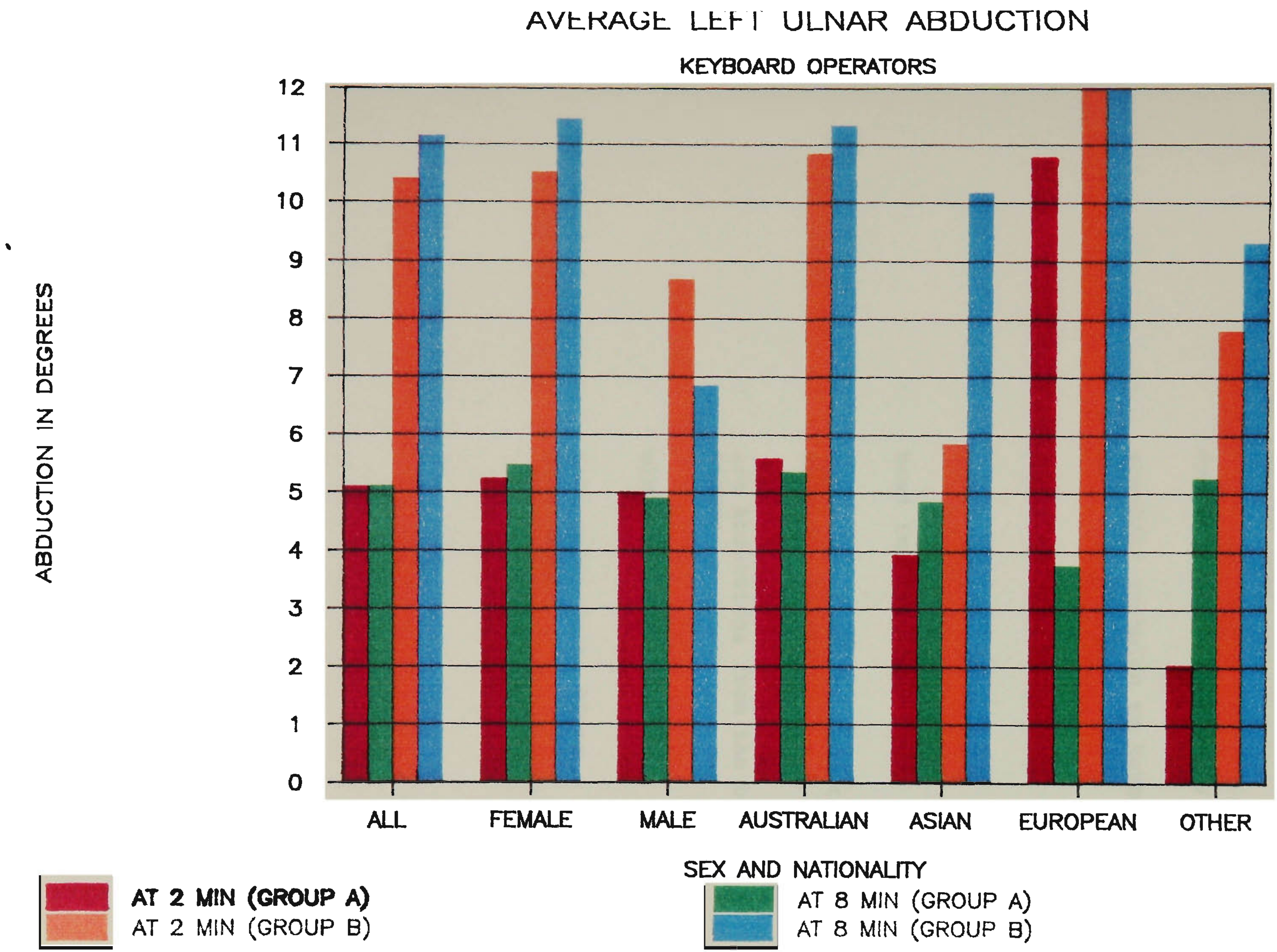



ELBOW ANGLE
AVERAGE OF 2 & 8 MIN POSITIONS
NUMBER OF MEASUREMENTS
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
UP TO 80
81–85
86–90
91–95
96–100
101–105
106–110
OVER 110
ANGLE IN DEGREES
GROUP – A
GROUP – B


AVERAGE ELBOW ANGLE
KEYBOARD OPERATORS
ANGLE IN DEGREES
120
110
100
90
80
70
60
50
40
30
20
10
0
ALL
FEMALE
MALE
AUSTRALIAN
ASIAN
EUROPEAN
OTHER
SEX AND NATIONALITY
AT 2 MIN (GROUP A)
AT 2 MIN (GROUP B)
AT 8 MIN (GROUP A)
AT 8 MIN (GROUP B)



LEFT ULNAR ABDUCTION
AVERAGE OF 2 & 8 MIN POSITIONS
NUMBER OF MEASUREMENTS
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
0–2
3–4
5–6
7–8
9–10
11–12
13–14
15–16
17–18
OVER 18
ABDUCTION IN DEGREES
GROUP – A
GROUP – B



AVERAGE LEFT ULNAR ABDUCTION
KEYBOARD OPERATORS
ABDUCTION IN DEGREES
0
1
2
3
4
5
6
7
8
9
10
11
12
ALL
FEMALE
MALE
AUSTRALIAN
ASIAN
EUROPEAN
OTHER
SEX AND NATIONALITY
AT 2 MIN (GROUP A)
AT 2 MIN (GROUP B)
AT 8 MIN (GROUP A)
AT 8 MIN (GROUP B)

APPENDICES

APPENDIX C - Separate Scattergrams with "Line-of-Best-Fit" Projections for Experimental Groups A and B, showing the results for:-

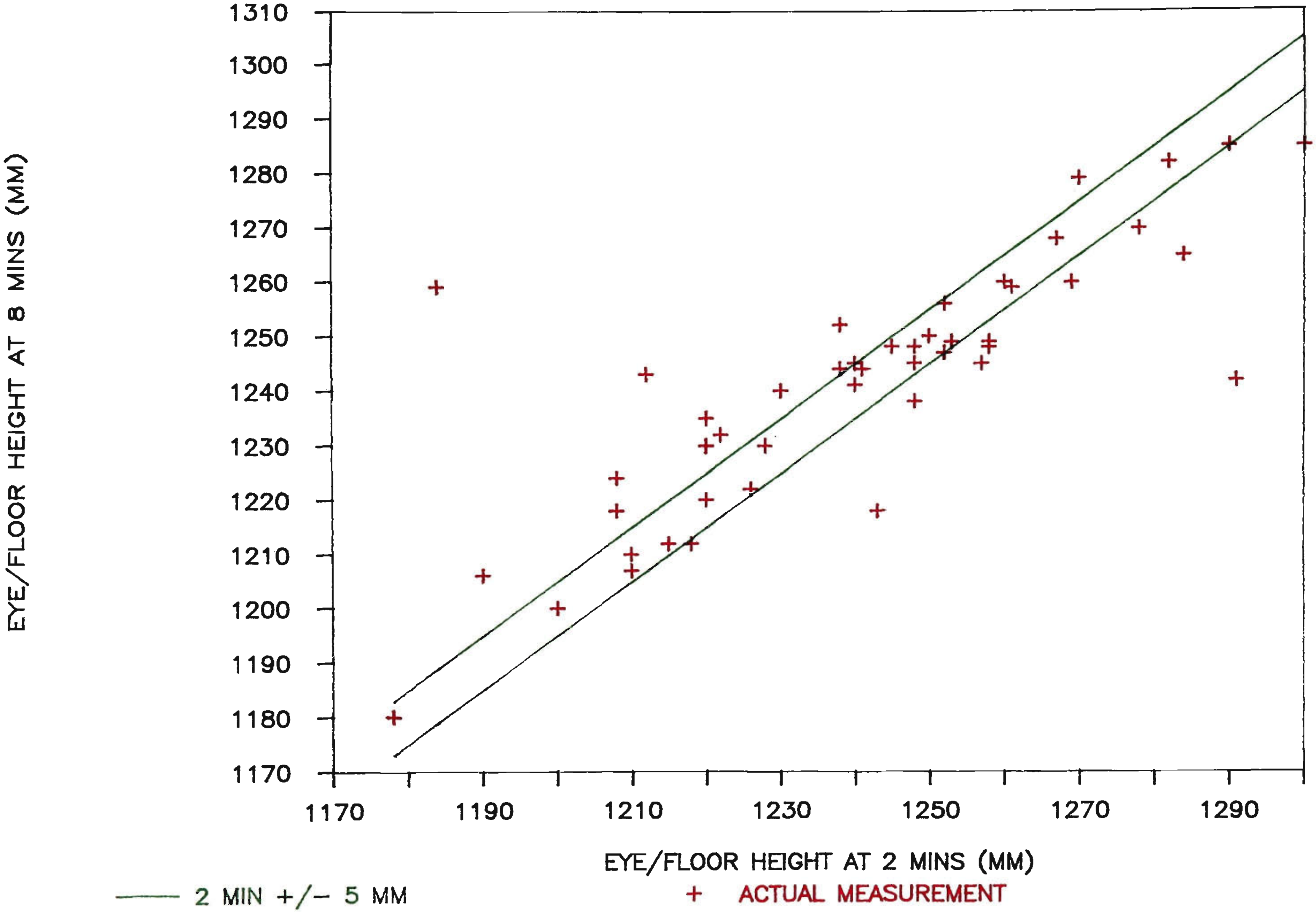
- eye to floor measurments;
- shoulder acromion to keyboard home row heights;
- eye to copy distances;
- trunk inclinations;
- head inclinations;
- upper arm flexions from the shoulder joints;
- arm abductions from the body sides;
- elbow angles;
- left wrist-joint ulnar abductions.

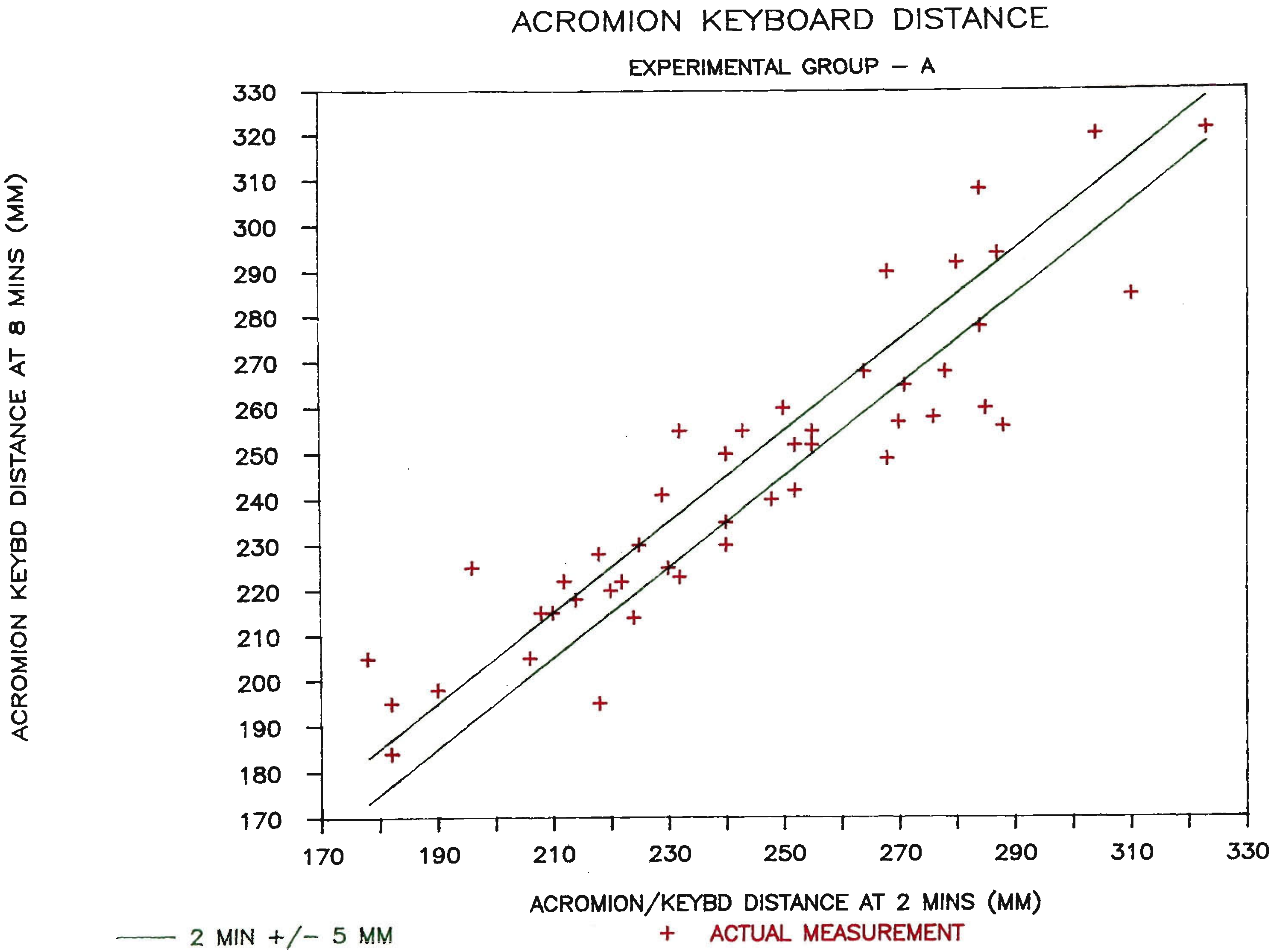
2 MIN AND 8 MIN POSITIONS GROUP - A

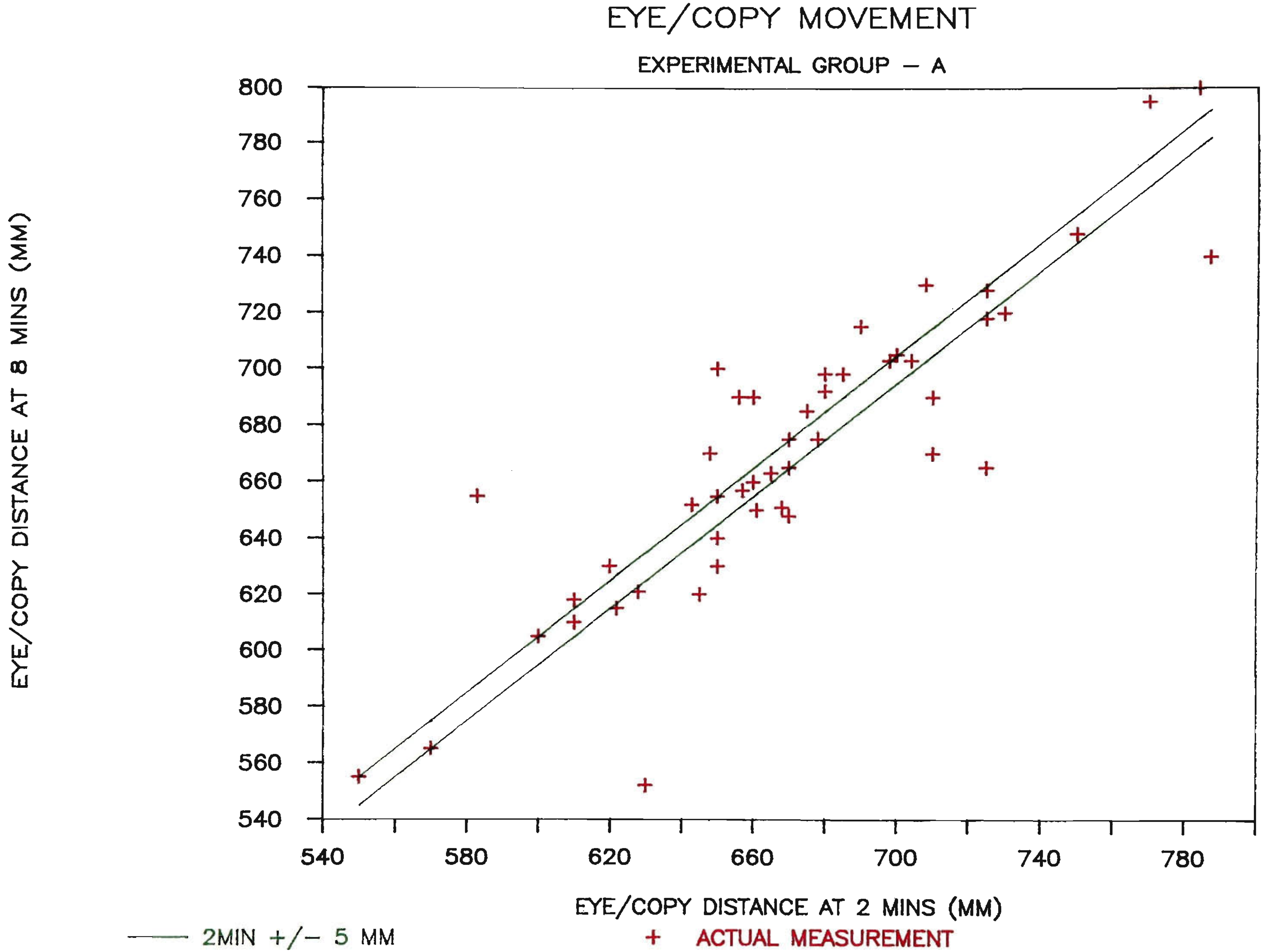
(GRAPHS)

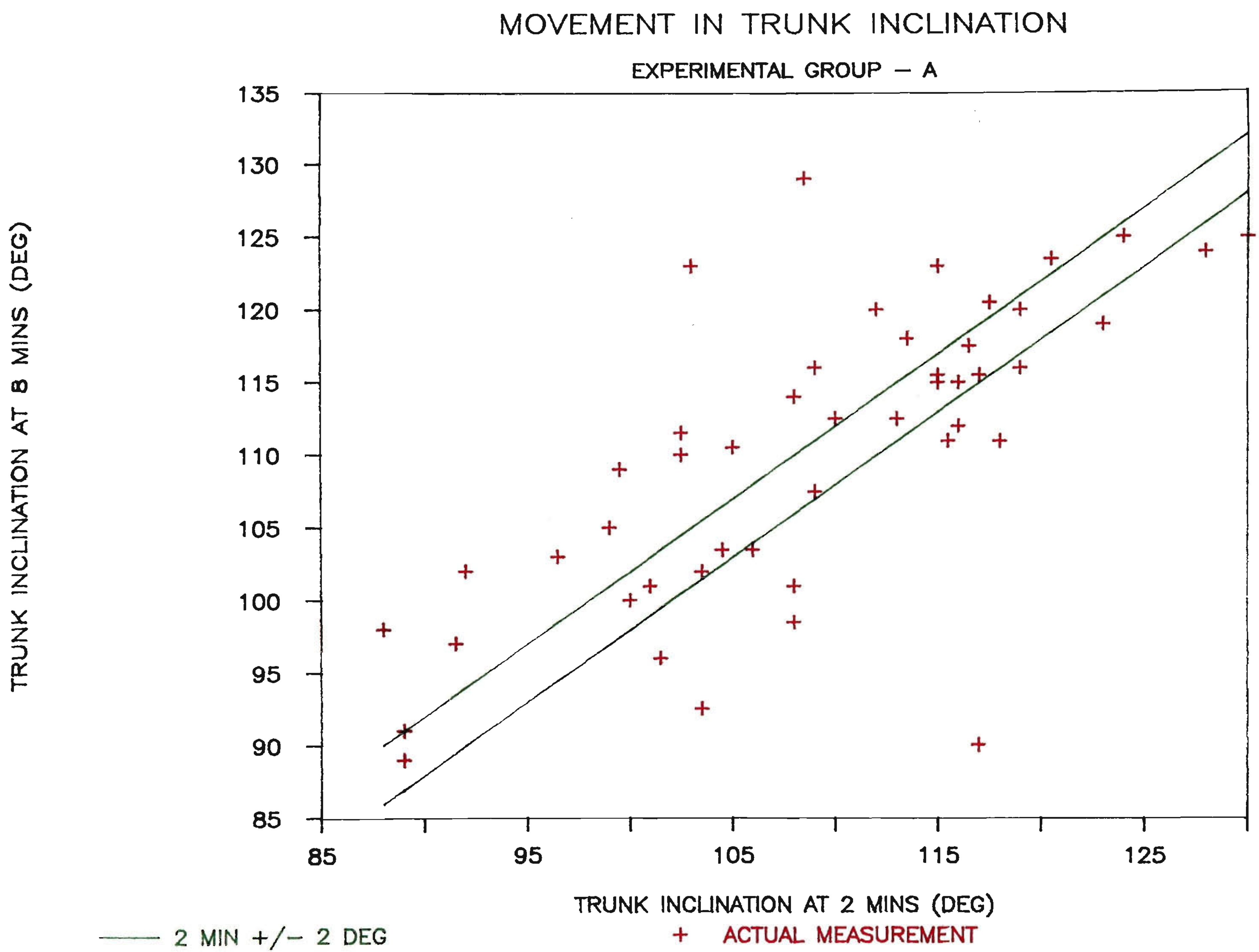
EYE/FLOOR MOVEMENT

EXPERIMENTAL GROUP – A



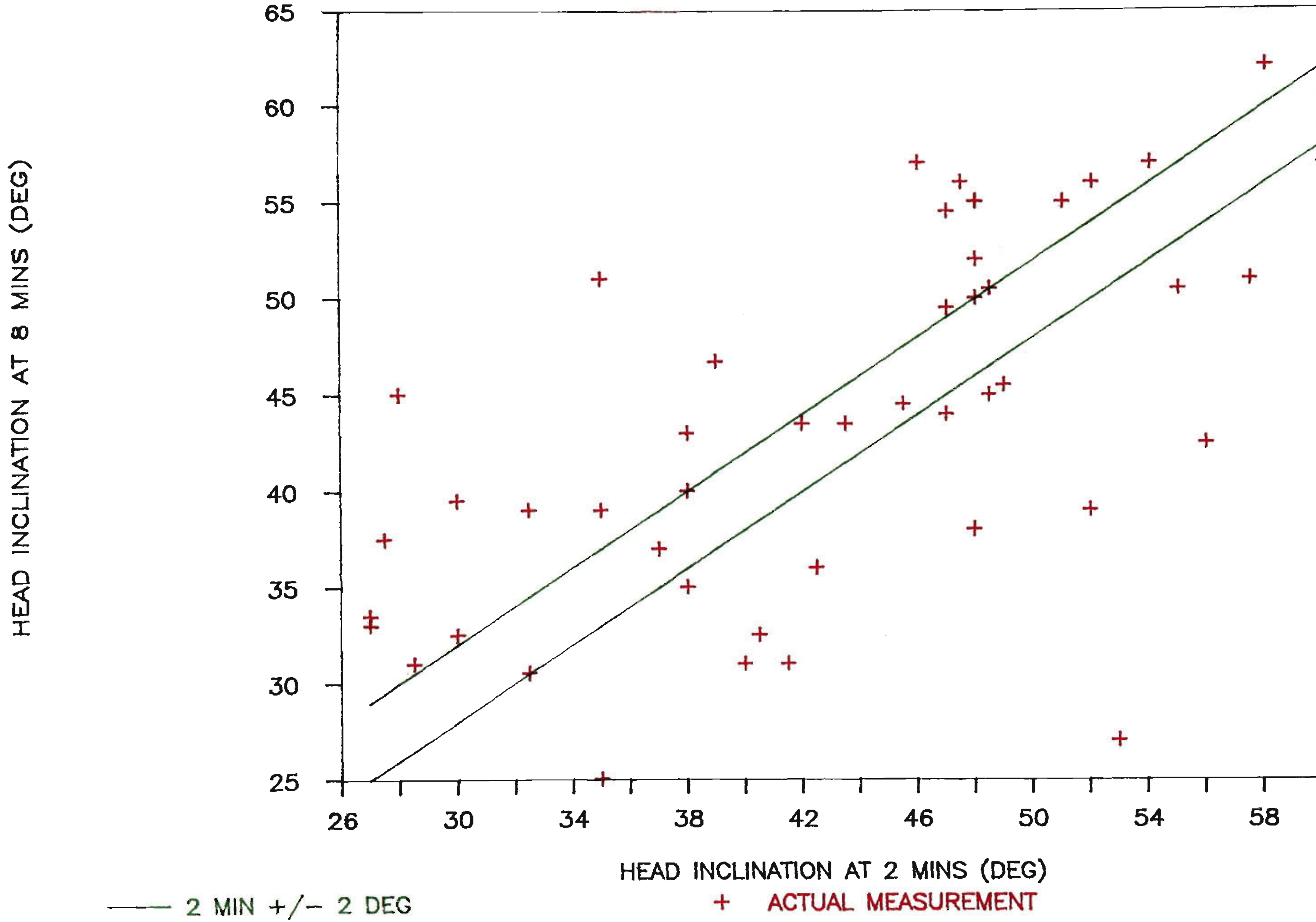

ACROMION KEYBOARD DISTANCE
EXPERIMENTAL GROUP – A
330
320
310
300
290
280
270
260
250
240
230
220
210
200
190
180
170
170
190
210
230
250
270
290
310
330
ACROMION KEYBD DISTANCE AT 8 MINS (MM)
ACROMION/KEYBD DISTANCE AT 2 MINS (MM)
2 MIN +/– 5 MM
+ ACTUAL MEASUREMENT

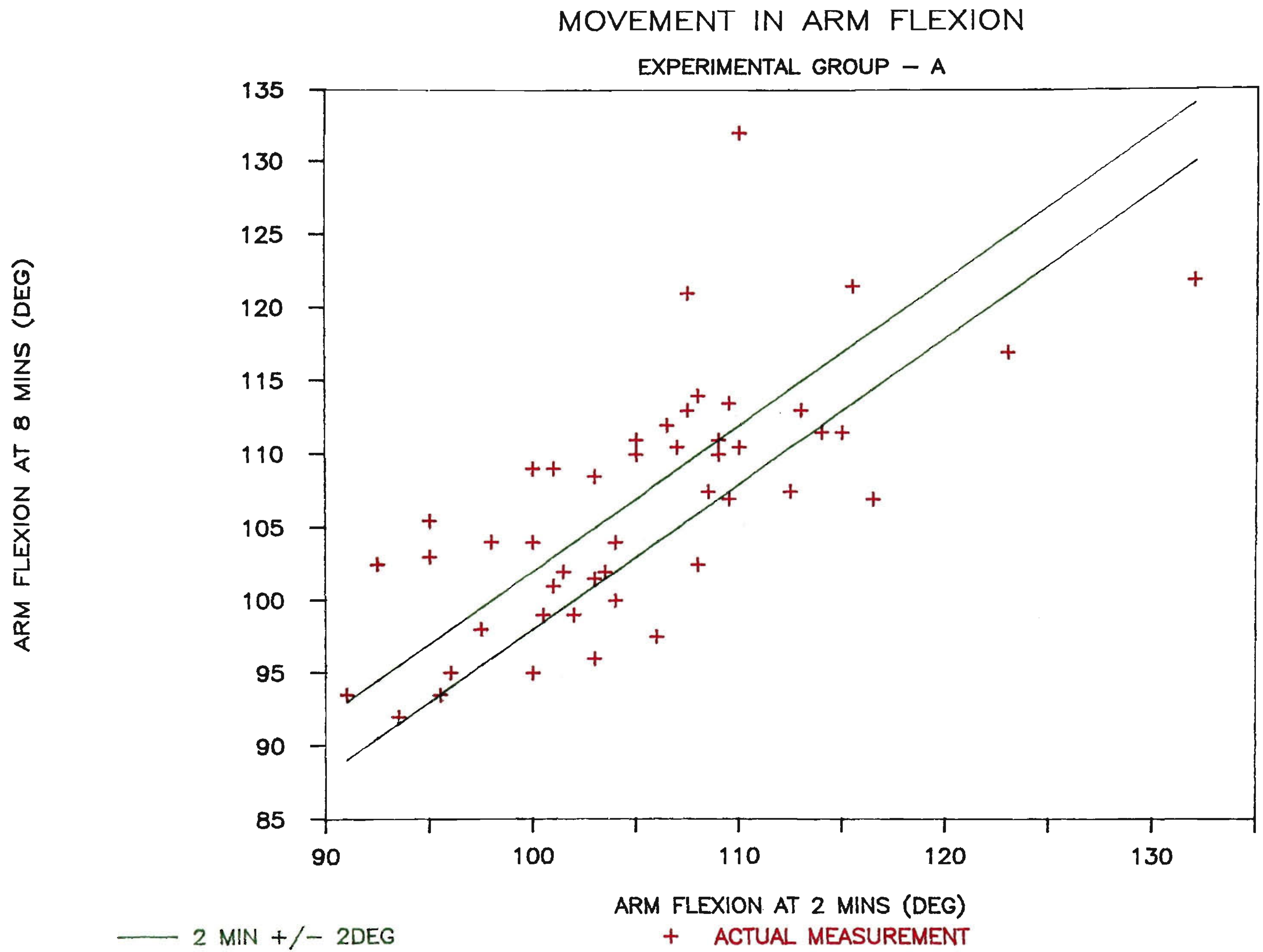

EYE/COPY MOVEMENT
EXPERIMENTAL GROUP – A
EYE/COPY DISTANCE AT 8 MINS (MM)
800
780
760
740
720
700
680
660
640
620
600
580
560
540
540
580
620
660
700
740
780
EYE/COPY DISTANCE AT 2 MINS (MM)
2MIN +/– 5 MM
+ ACTUAL MEASUREMENT


MOVEMENT IN TRUNK INCLINATION
EXPERIMENTAL GROUP – A
TRUNK INCLINATION AT 8 MINS (DEG)
135
130
125
120
115
110
105
100
95
90
85
85
95
105
115
125
TRUNK INCLINATION AT 2 MINS (DEG)
2 MIN +/– 2 DEG
+ ACTUAL MEASUREMENT

MOVEMENT IN HEAD INCLINATION

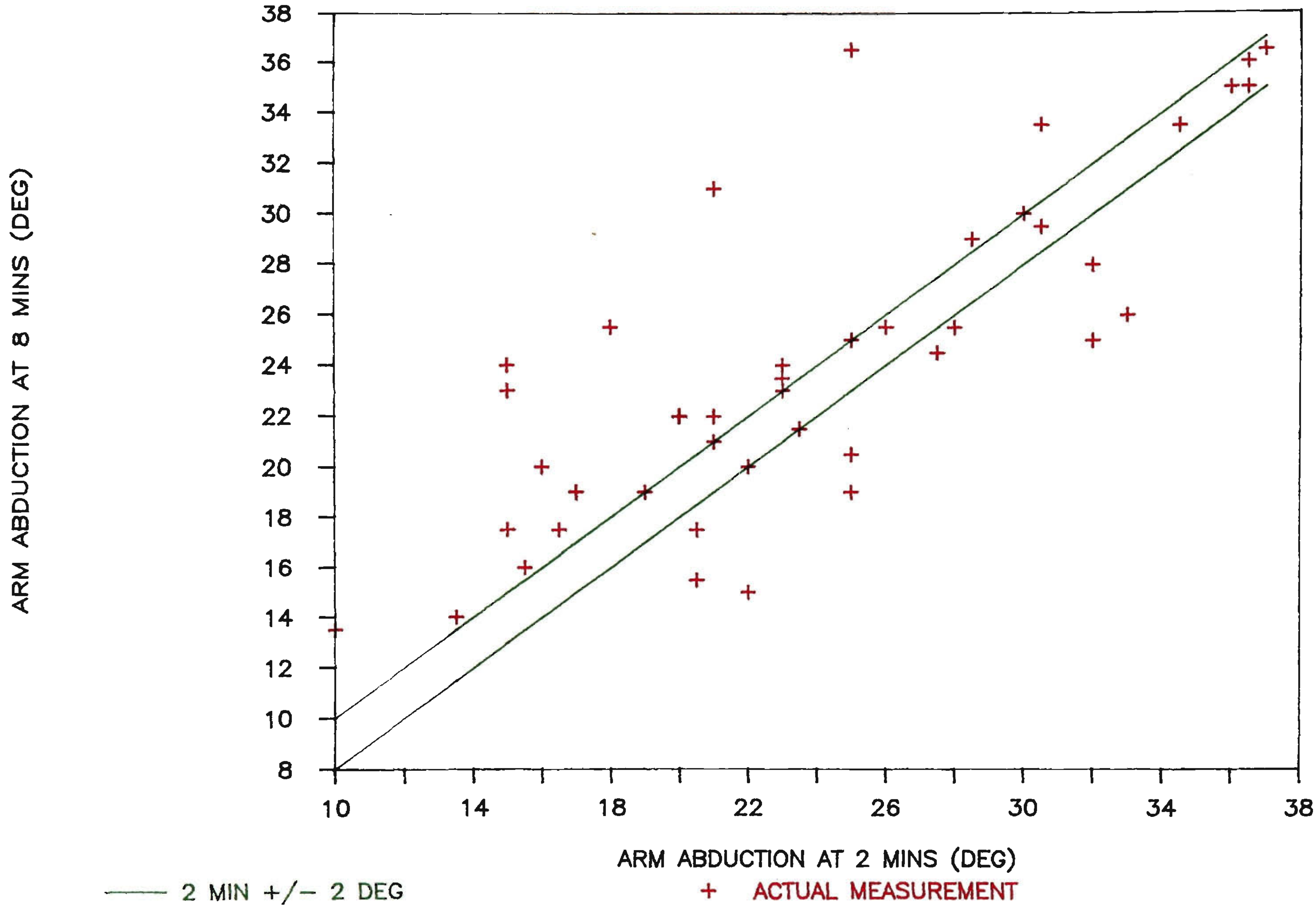
EXPERIMENTAL GROUP – A




MOVEMENT IN ARM FLEXION
EXPERIMENTAL GROUP – A
ARM FLEXION AT 8 MINS (DEG)
135
130
125
120
115
110
105
100
95
90
85
90
100
110
120
130
ARM FLEXION AT 2 MINS (DEG)
2 MIN +/– 2DEG
+ ACTUAL MEASUREMENT

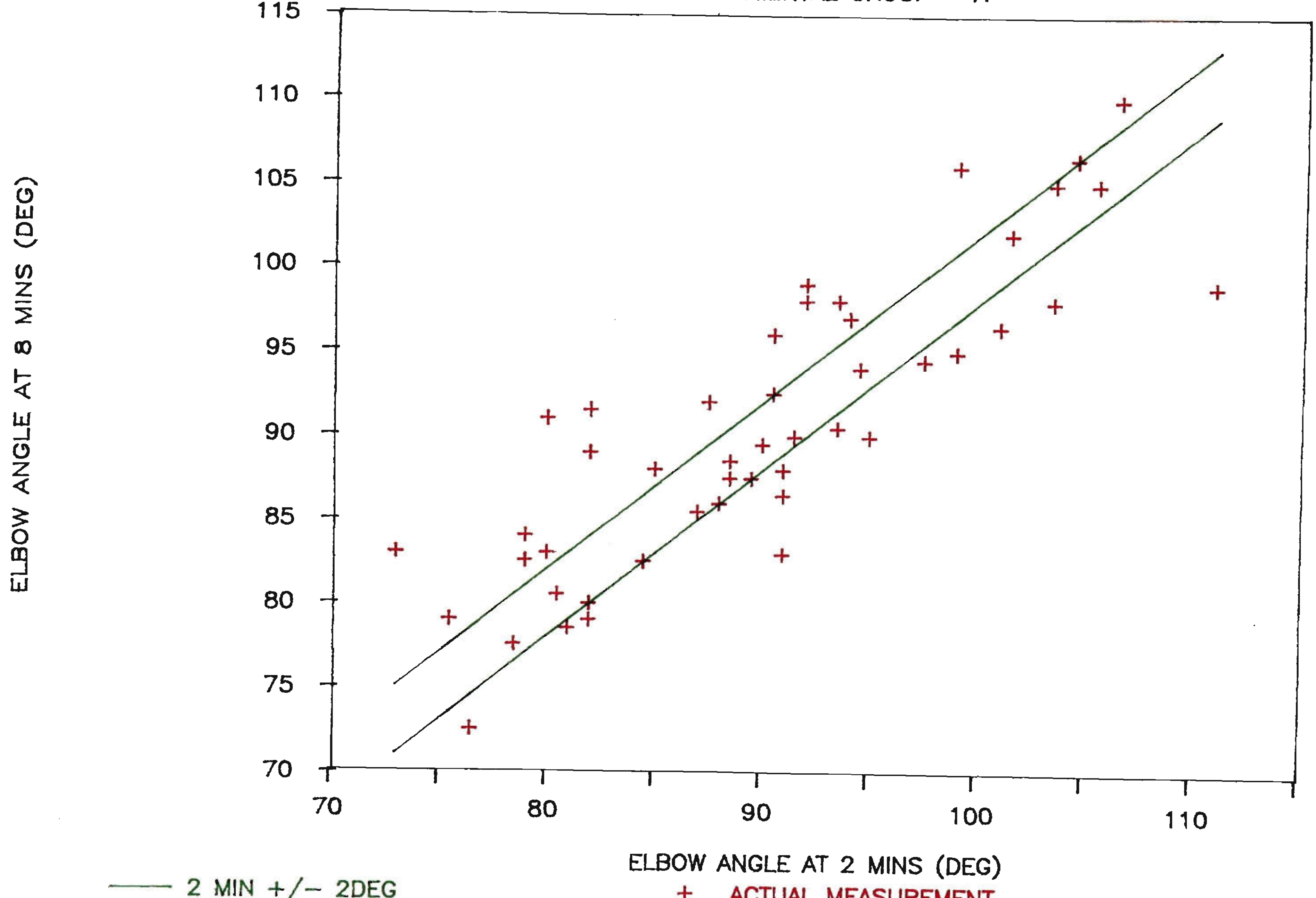
MOVEMENT IN ARM ABDUCTION

EXPERIMENTAL GROUP – A

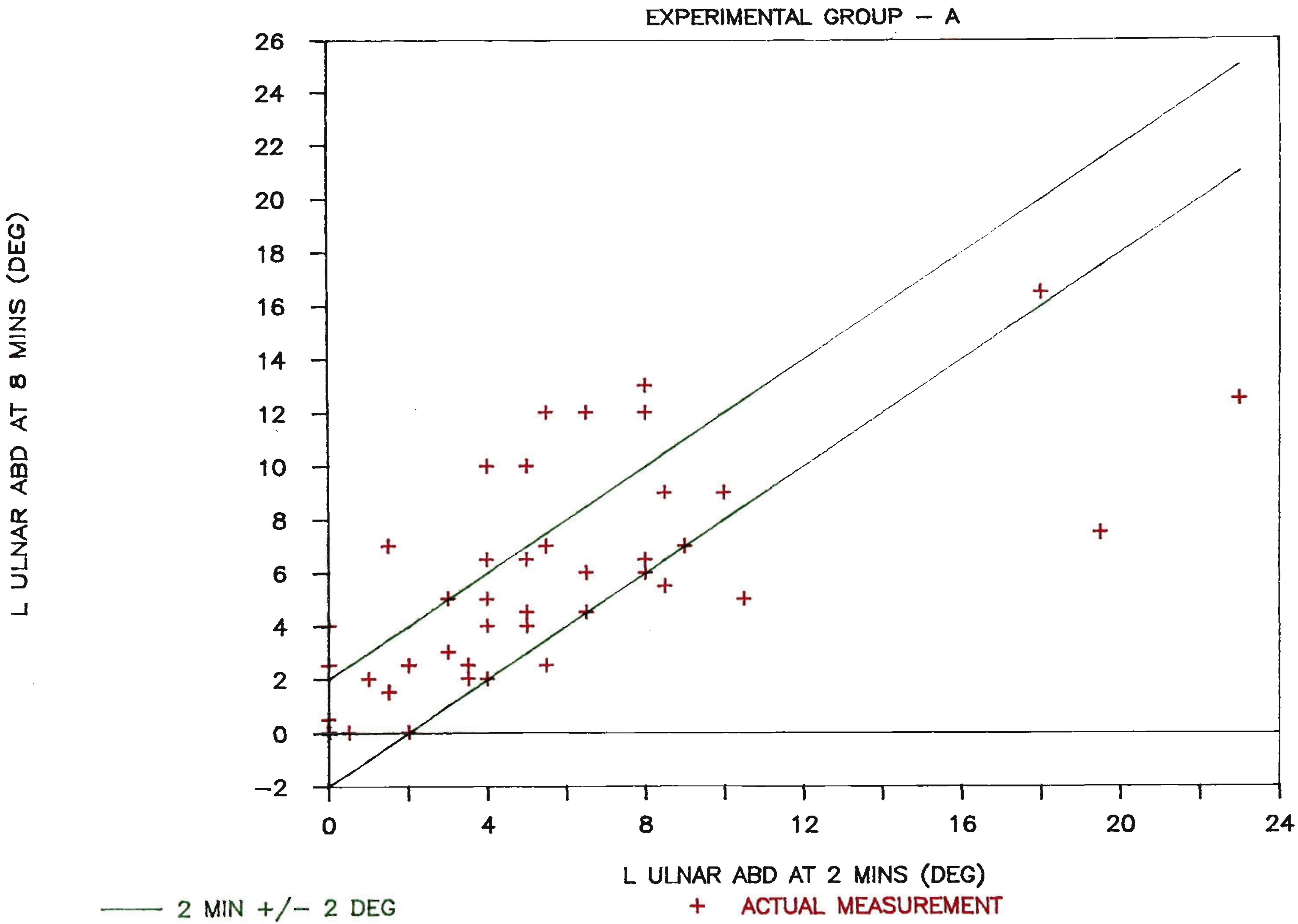


MOVEMENT IN ELBOW ANGLE

EXPERIMENTAL GROUP – A

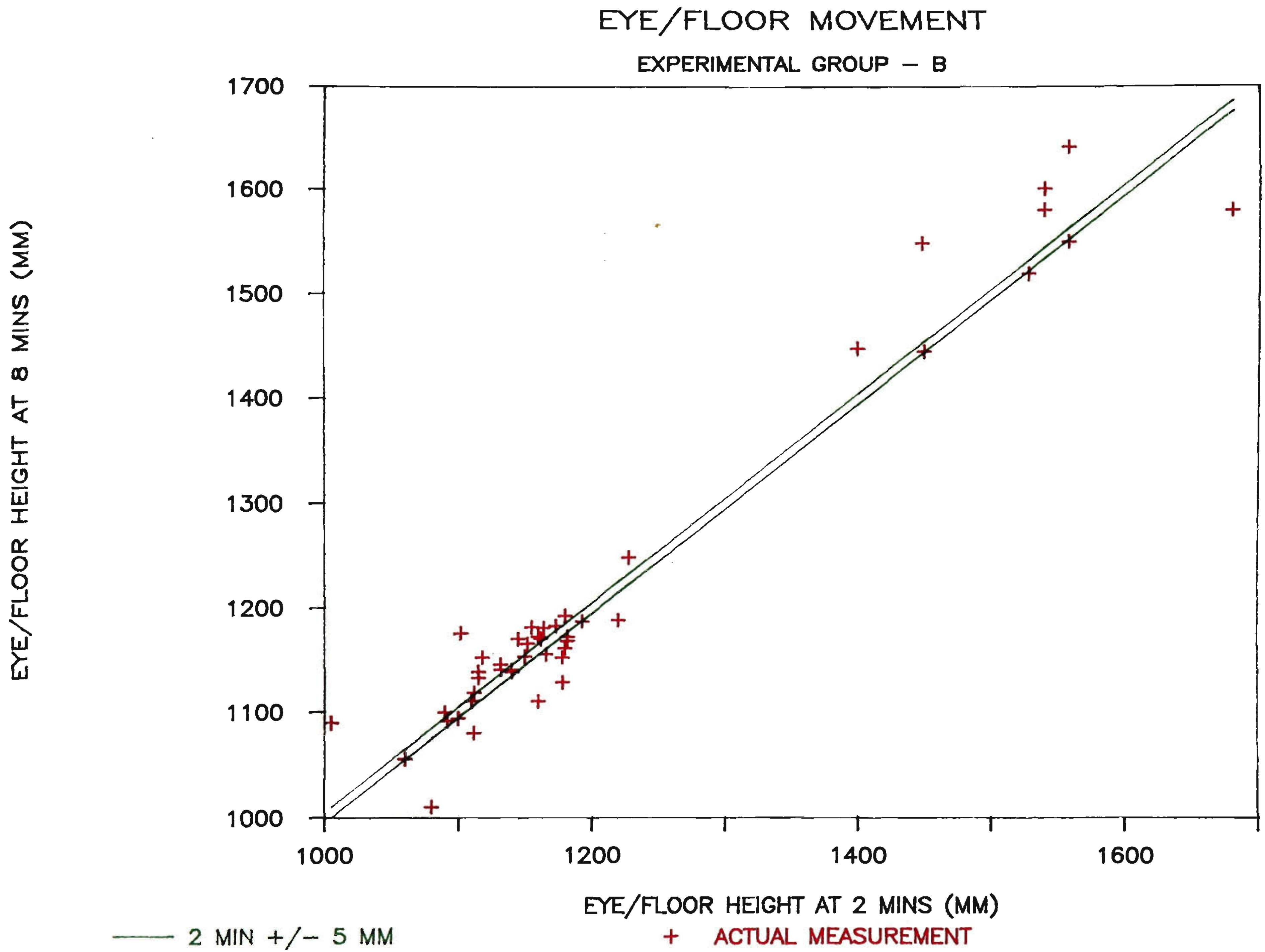


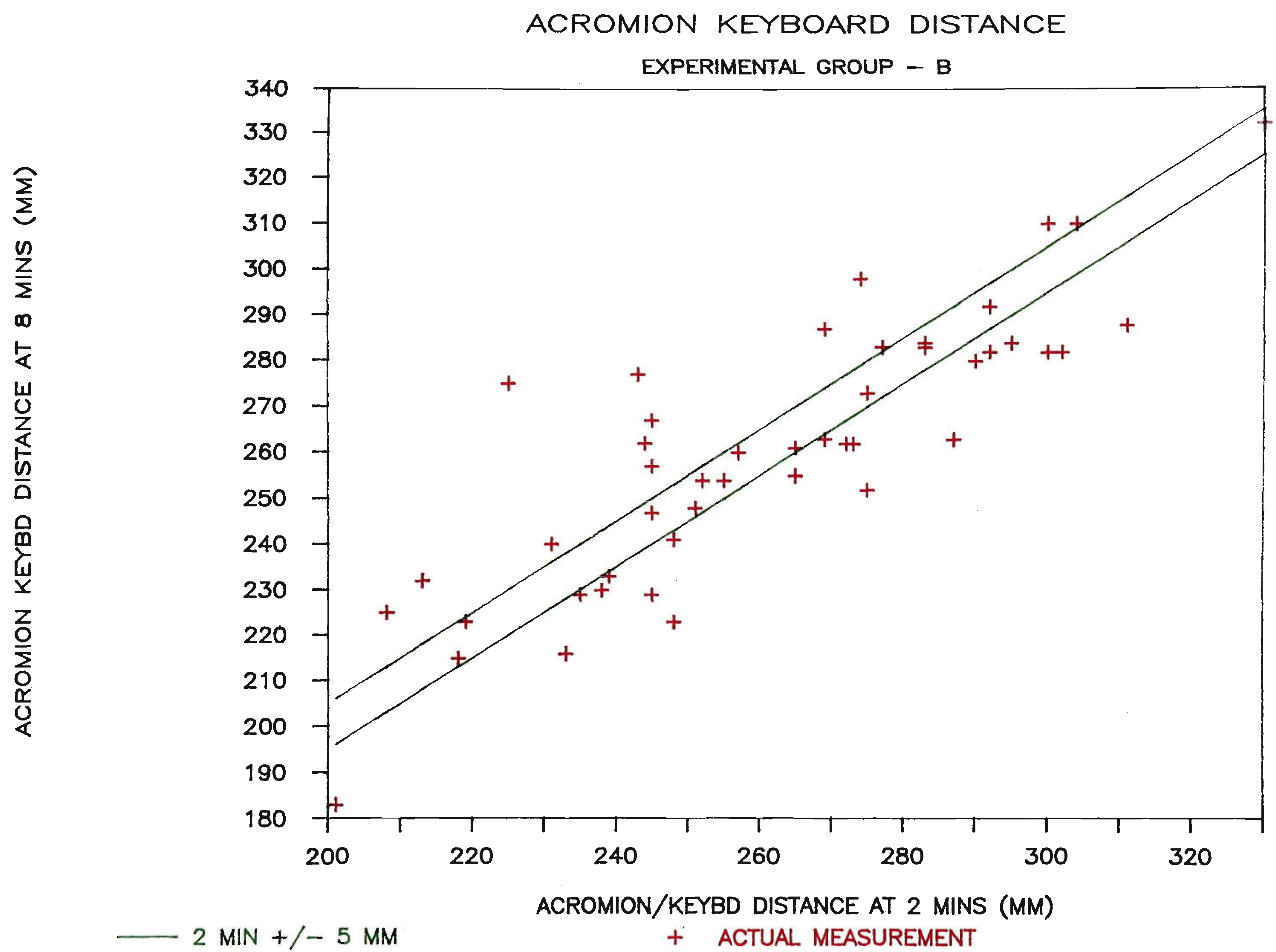
MOVEMENT IN LEFT ULNAR ABDUCTION

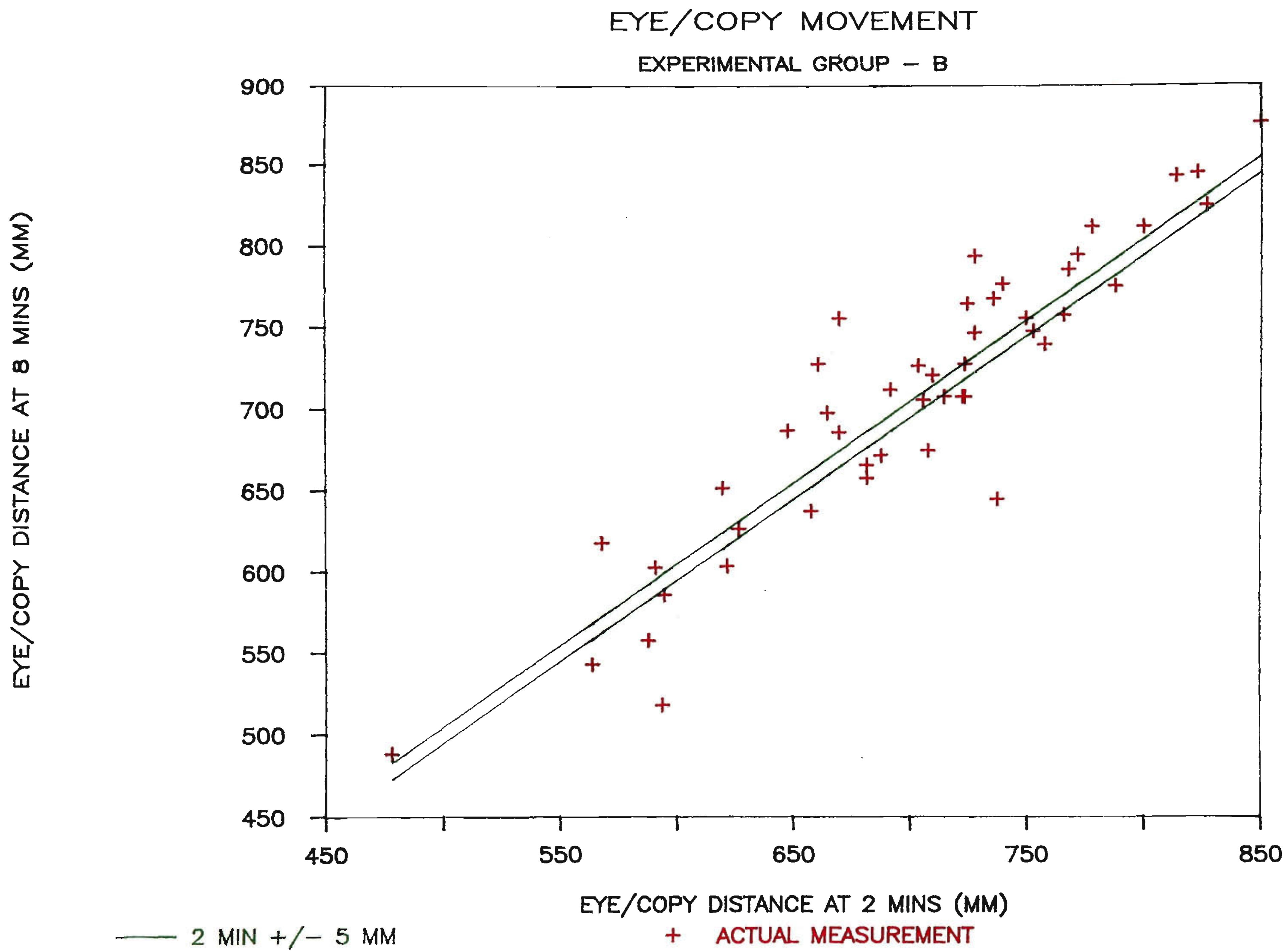


2 MIN AND 8 MIN POSITIONS GROUP - B

(GRAPHS)


EYE/FLOOR MOVEMENT
EXPERIMENTAL GROUP – B
1700
1600
1500
1400
1300
1200
1100
1000
1000
1200
1400
1600
EYE/FLOOR HEIGHT AT 8 MINS (MM)
EYE/FLOOR HEIGHT AT 2 MINS (MM)
2 MIN +/– 5 MM
+ ACTUAL MEASUREMENT

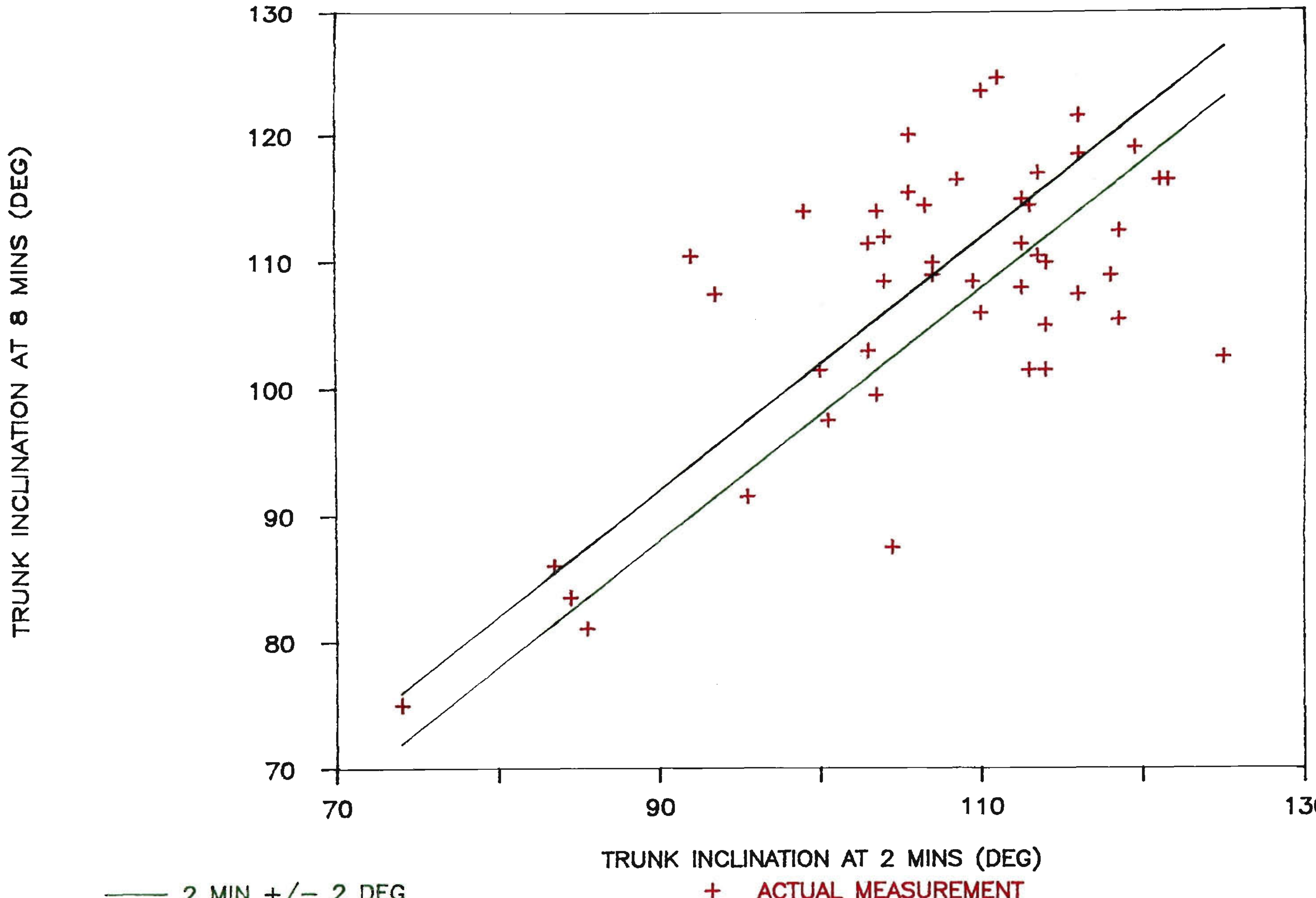

ACROMION KEYBOARD DISTANCE
EXPERIMENTAL GROUP – B
ACROMION KEYBD DISTANCE AT 8 MINS (MM)
340
330
320
310
300
290
280
270
260
250
240
230
220
210
200
190
180
200
220
240
260
280
300
320
ACROMION/KEYBD DISTANCE AT 2 MINS (MM)
2 MIN +/– 5 MM
+ ACTUAL MEASUREMENT

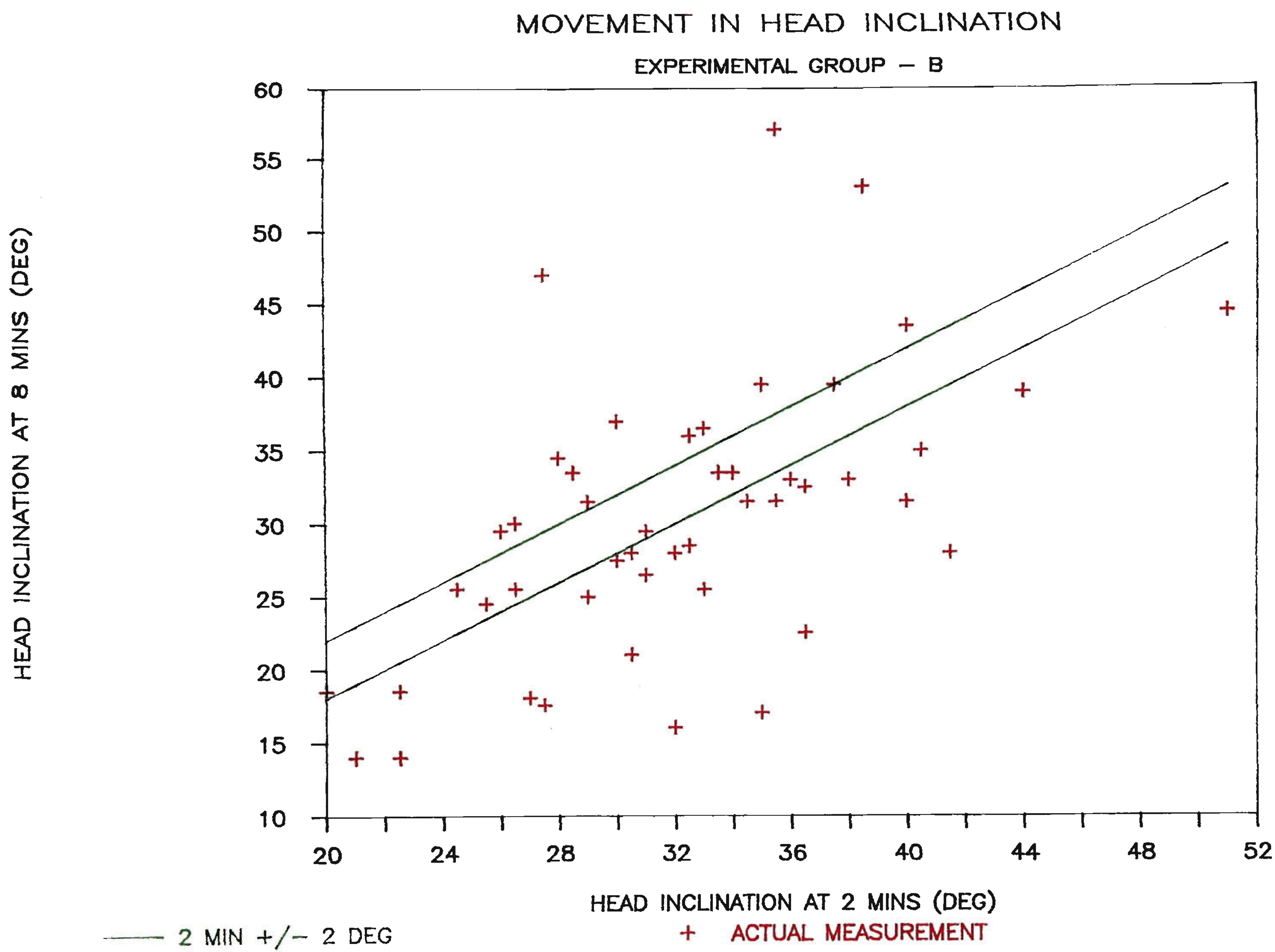


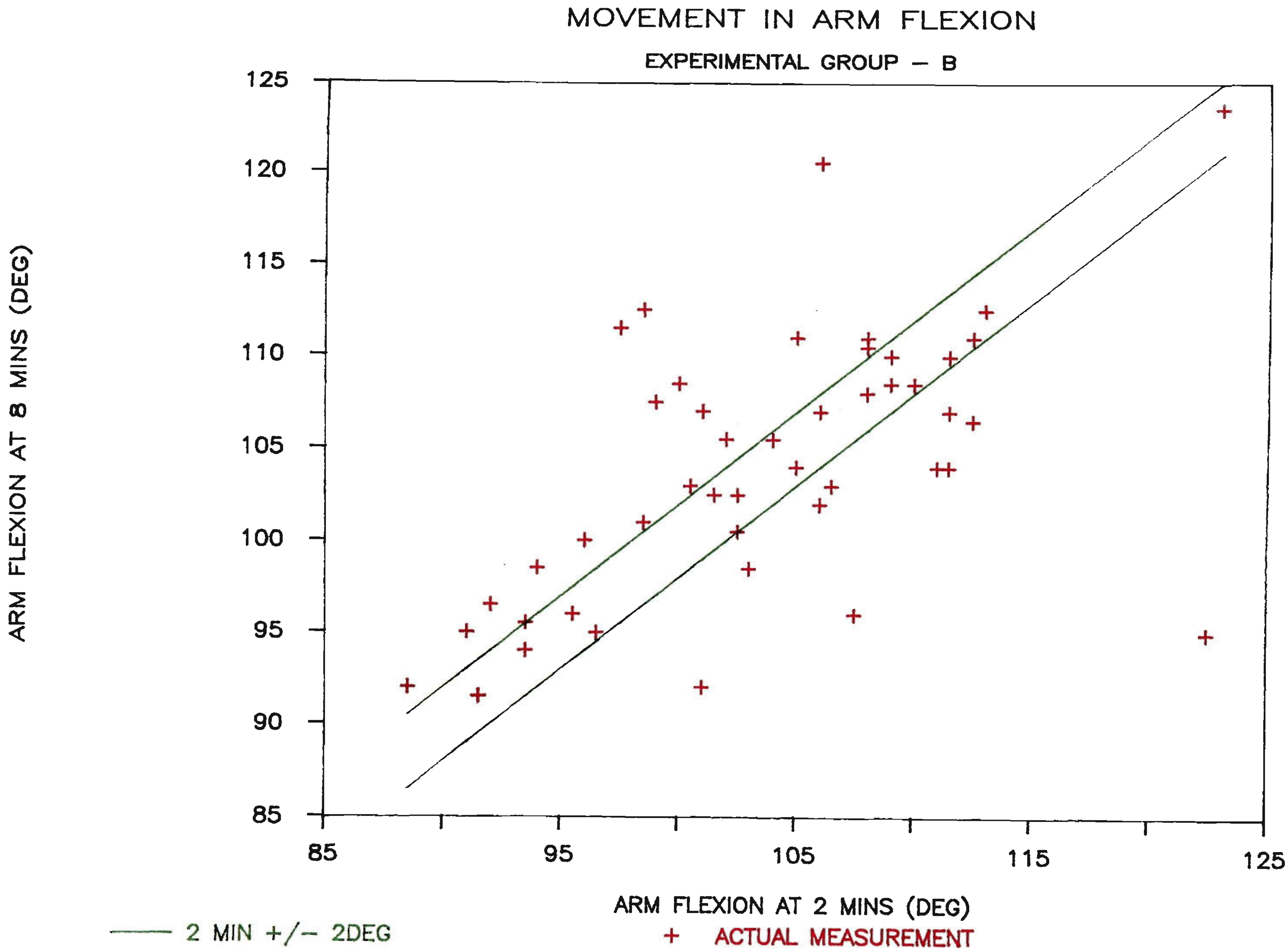
EYE/COPY MOVEMENT
EXPERIMENTAL GROUP – B
900
850
800
750
700
650
600
550
500
450
EYE/COPY DISTANCE AT 8 MINS (MM)
450
550
650
750
850
EYE/COPY DISTANCE AT 2 MINS (MM)
2 MIN +/– 5 MM
+ ACTUAL MEASUREMENT

MOVEMENT IN TRUNK INCLINATION

EXPERIMENTAL GROUP – B



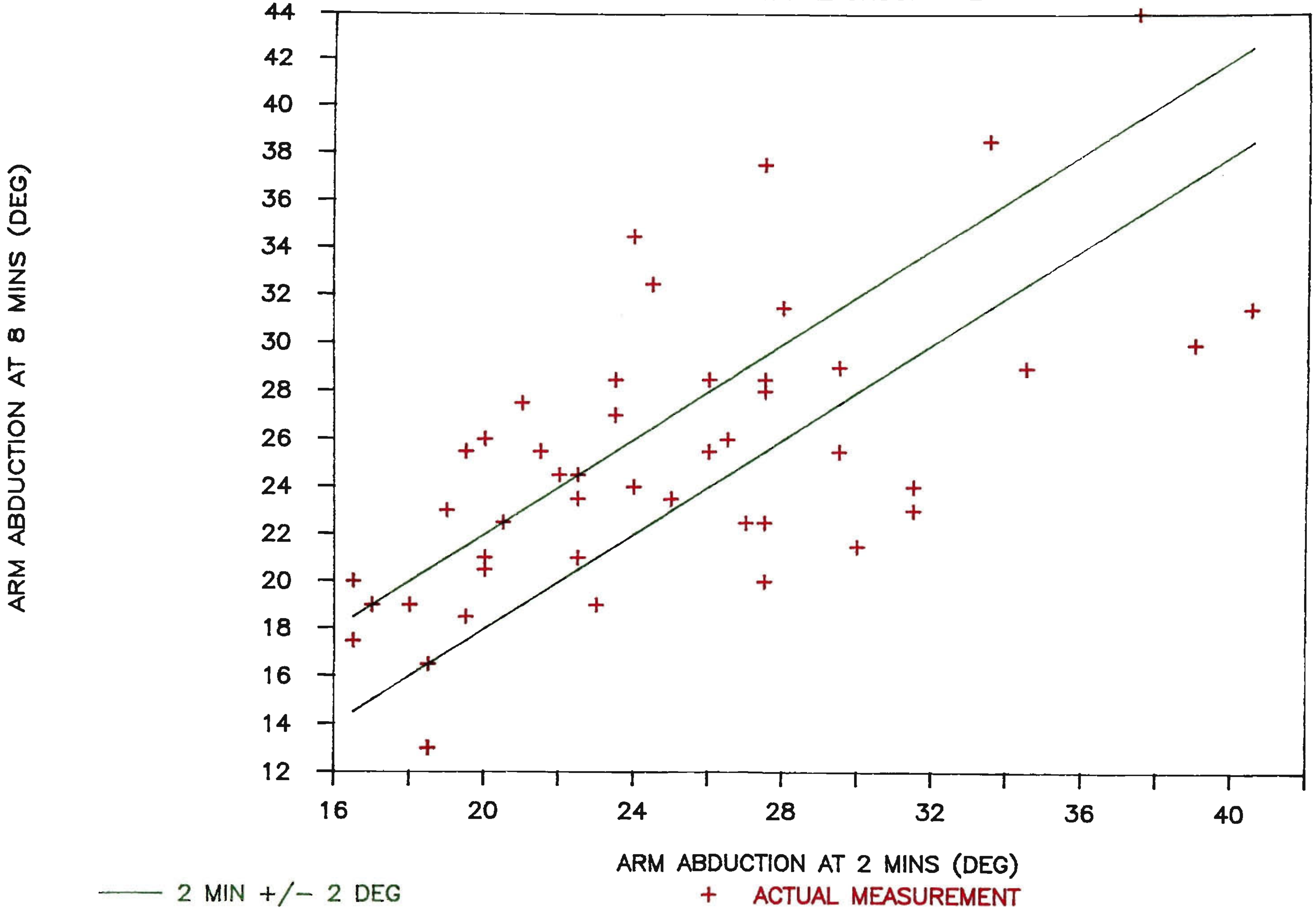

MOVEMENT IN HEAD INCLINATION
EXPERIMENTAL GROUP – B
HEAD INCLINATION AT 8 MINS (DEG)
60
55
50
45
40
35
30
25
20
15
10
20
24
28
32
36
40
44
48
52
HEAD INCLINATION AT 2 MINS (DEG)
2 MIN +/– 2 DEG
+ ACTUAL MEASUREMENT

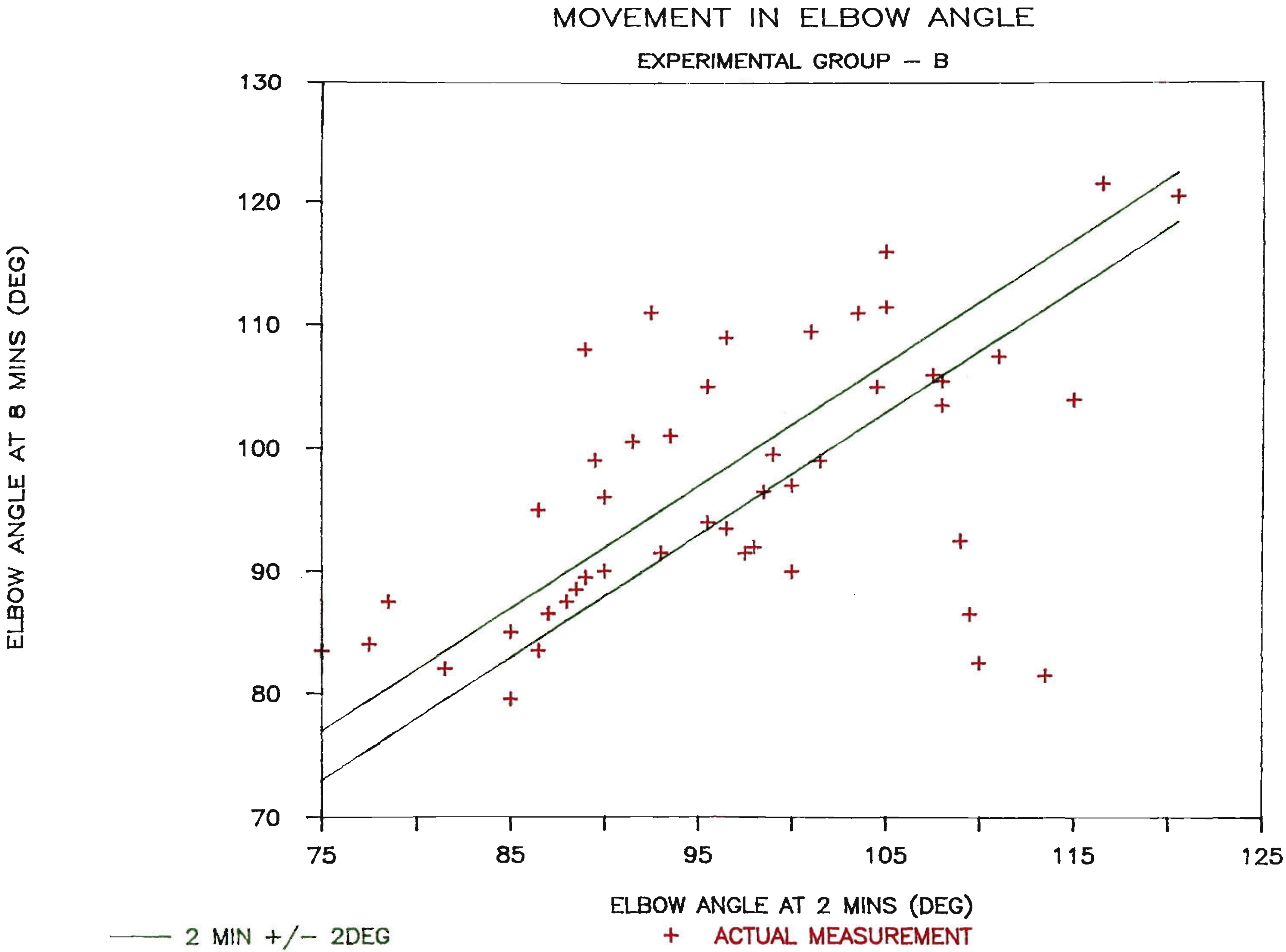


MOVEMENT IN ARM FLEXION
EXPERIMENTAL GROUP – B
ARM FLEXION AT 8 MINS (DEG)
125
120
115
110
105
100
95
90
85
85
95
105
115
125
ARM FLEXION AT 2 MINS (DEG)
2 MIN +/– 2DEG
+ ACTUAL MEASUREMENT

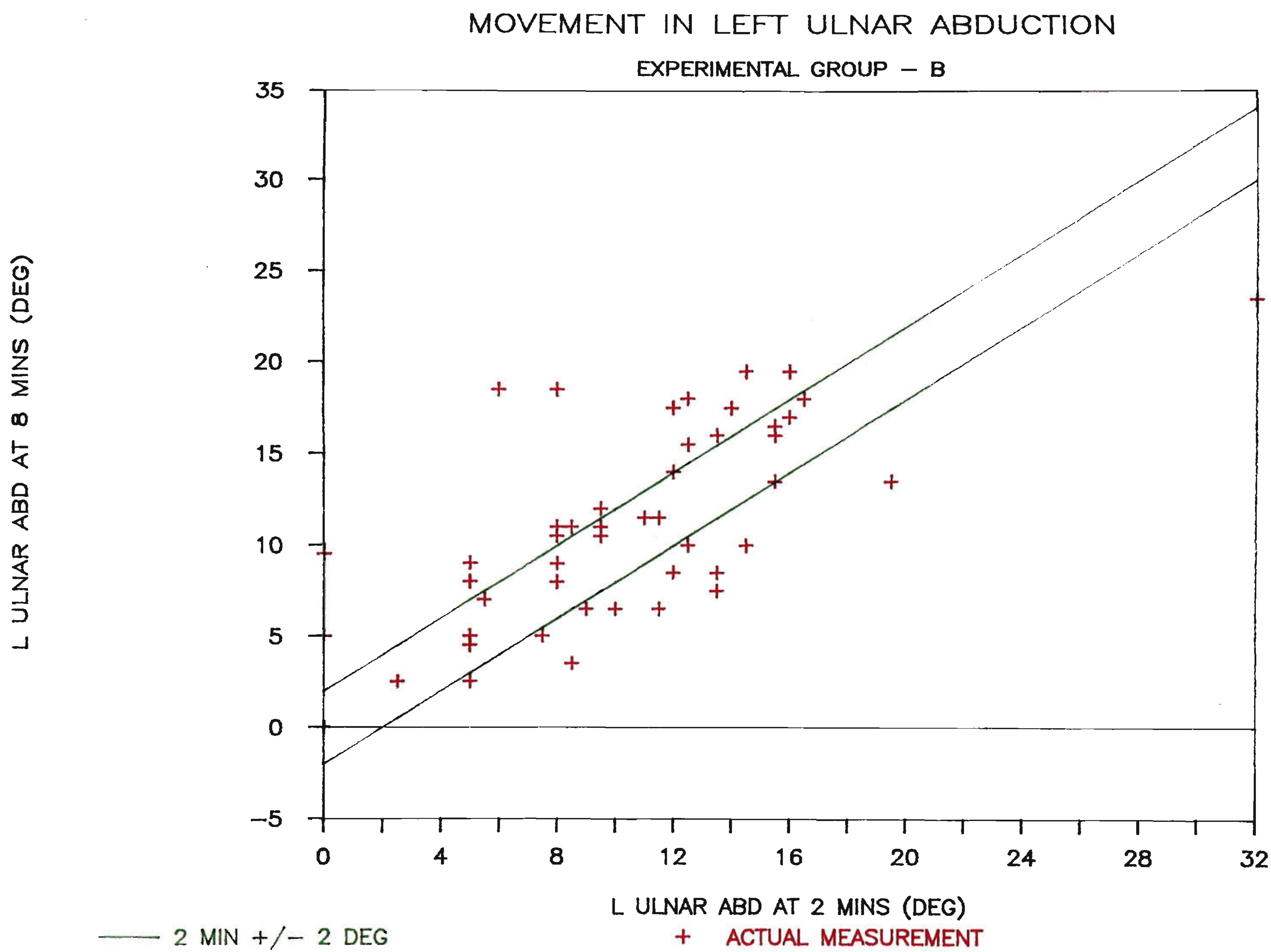
MOVEMENT IN ARM ABDUCTION

EXPERIMENTAL GROUP – B





MOVEMENT IN ELBOW ANGLE
EXPERIMENTAL GROUP – B
130
120
110
100
90
80
70
75
85
95
105
115
125
ELBOW ANGLE AT 8 MINS (DEG)
ELBOW ANGLE AT 2 MINS (DEG)
2 MIN +/– 2DEG
+ ACTUAL MEASUREMENT



MOVEMENT IN LEFT ULNAR ABDUCTION
EXPERIMENTAL GROUP – B
L ULNAR ABD AT 8 MINS (DEG)
35
30
25
20
15
10
5
0
–5
0
4
8
12
16
20
24
28
32
L ULNAR ABD AT 2 MINS (DEG)
2 MIN +/– 2 DEG
+ ACTUAL MEASUREMENT

APPENDICES

APPENDIX D - Separate Relationship Graphs from Experimental Groups A and B Including "Line fo Best Fit" Projections, showing the results for:-

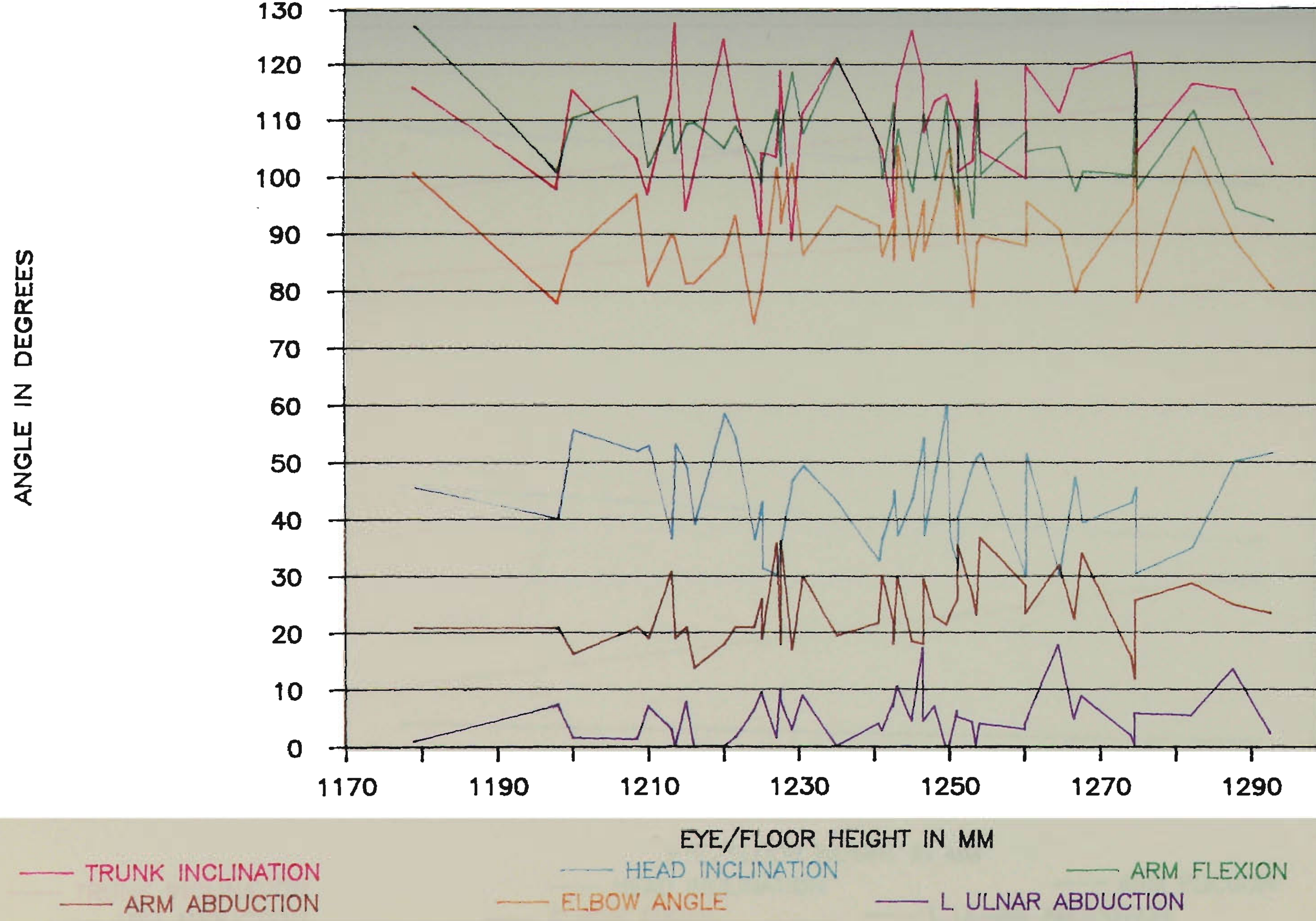
- eye to floor measurements;
- shoulder acromion to keyboard home row heights;
- eye to copy distances;

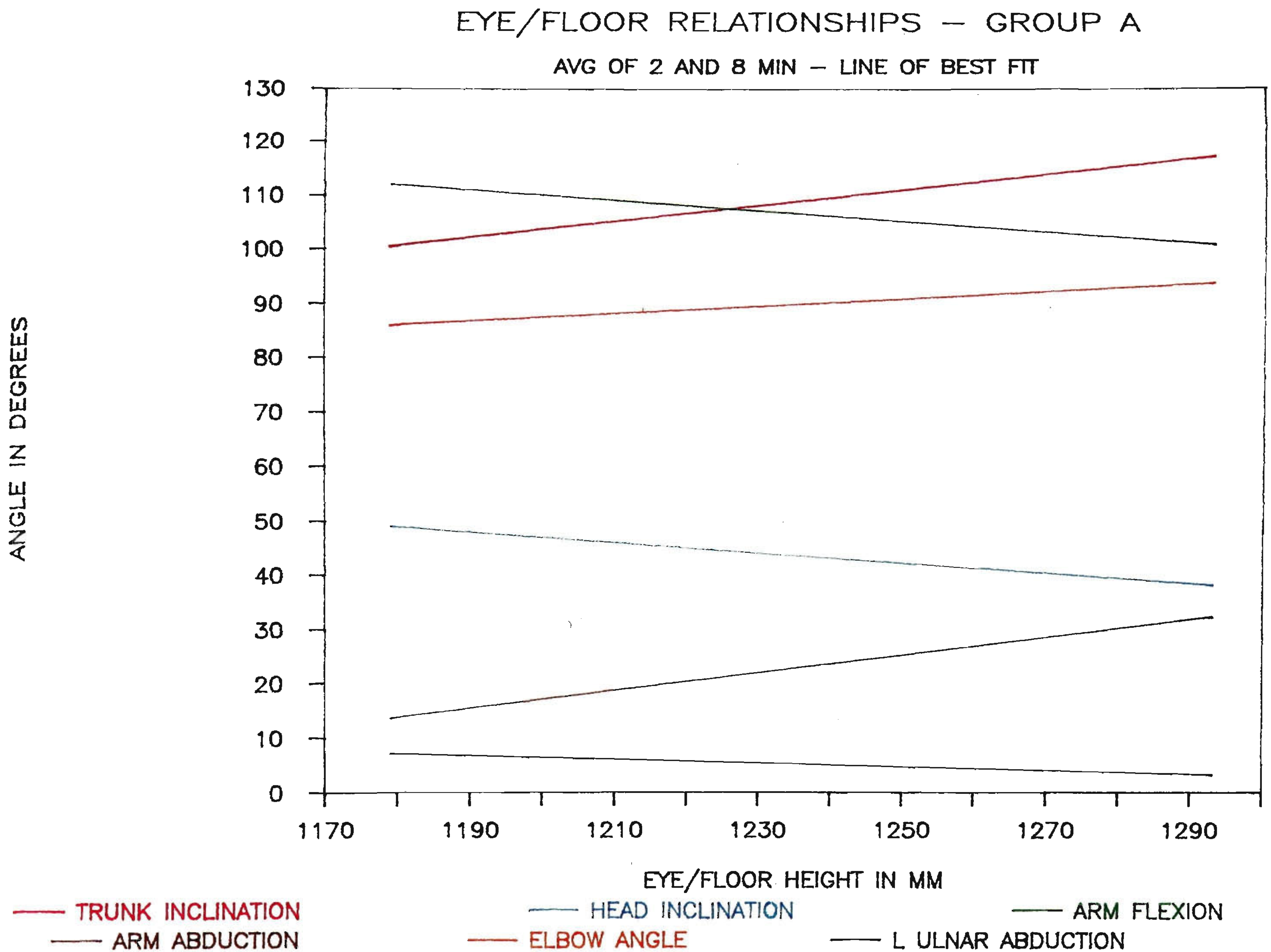
projected separately each against the angular measurements for:-

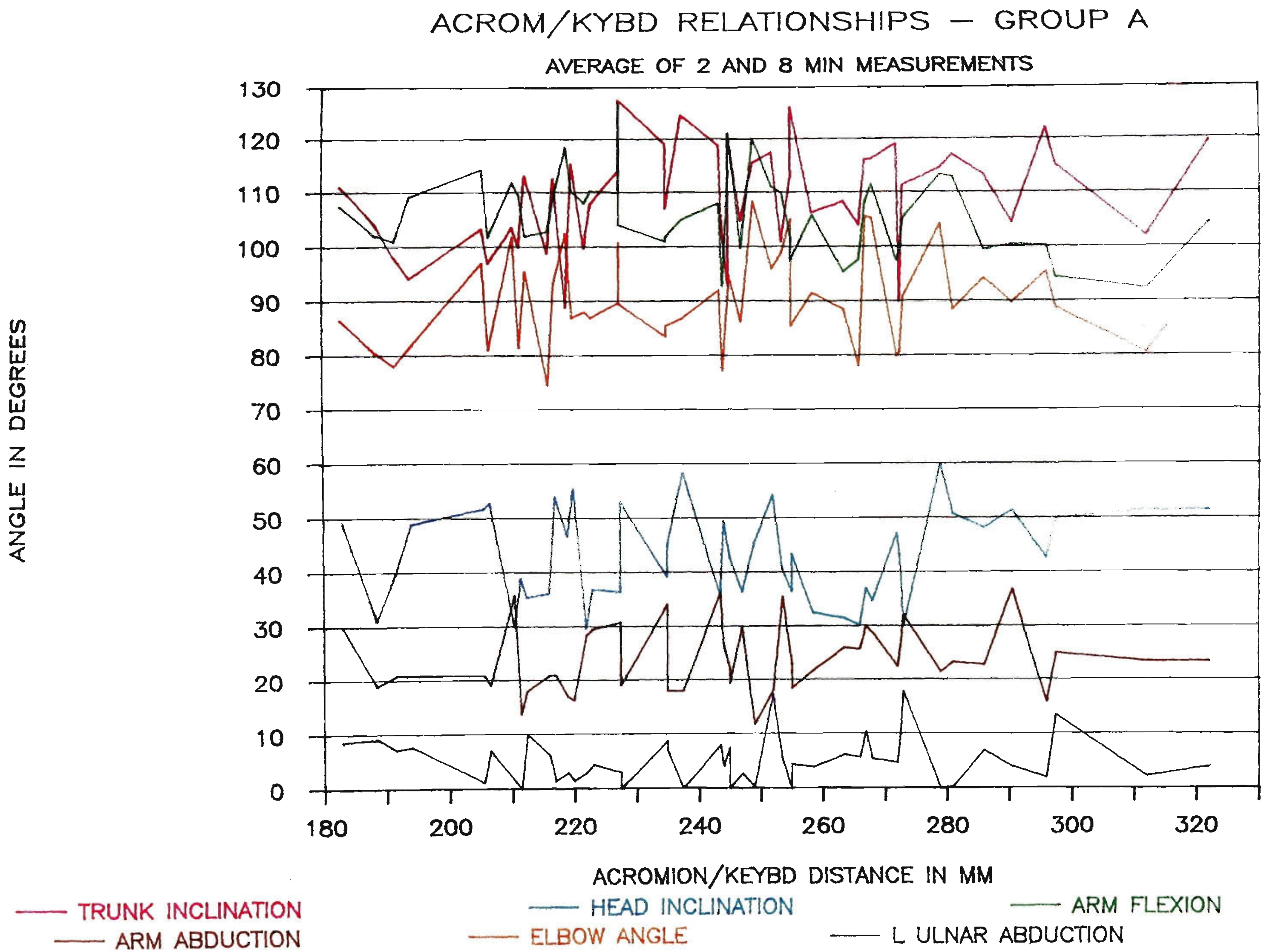
- trunk inclinations;
- head inclinations;
- upper arm flexions from the shoulder joints;
- arm abductions from the body sides;
- elbow angles;
- left wrist-joint ulnar abductions.

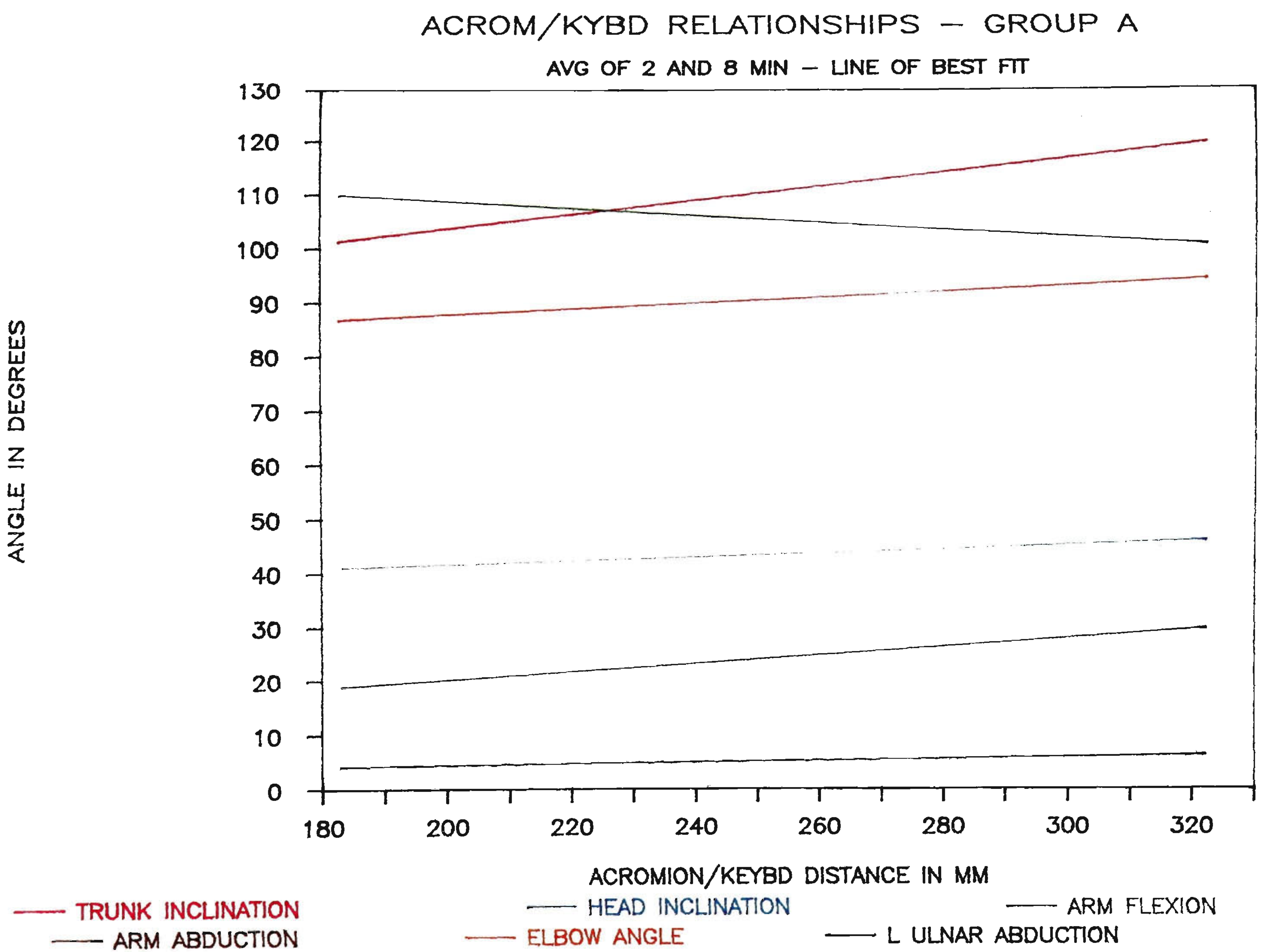
EYE/FLOOR RELATIONSHIPS — GROUP A

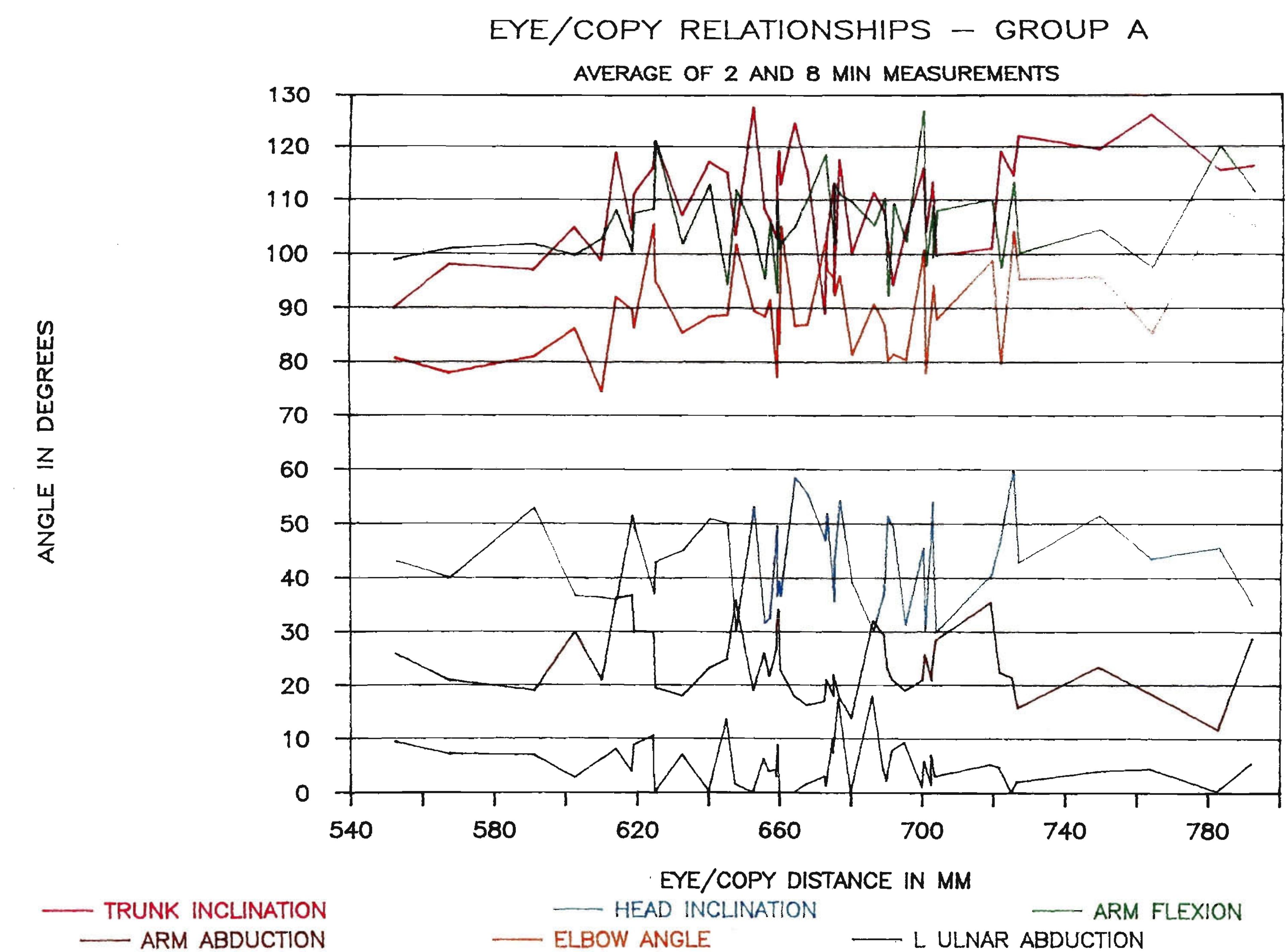
AVERAGE OF 2 AND 8 MIN MEASUREMENTS




EYE/FLOOR RELATIONSHIPS – GROUP A
AVG OF 2 AND 8 MIN – LINE OF BEST FIT
ANGLE IN DEGREES
130
120
110
100
90
80
70
60
50
40
30
20
10
0
1170
1190
1210
1230
1250
1270
1290
EYE/FLOOR HEIGHT IN MM
TRUNK INCLINATION
HEAD INCLINATION
ARM FLEXION
ARM ABDUCTION
ELBOW ANGLE
L ULNAR ABDUCTION

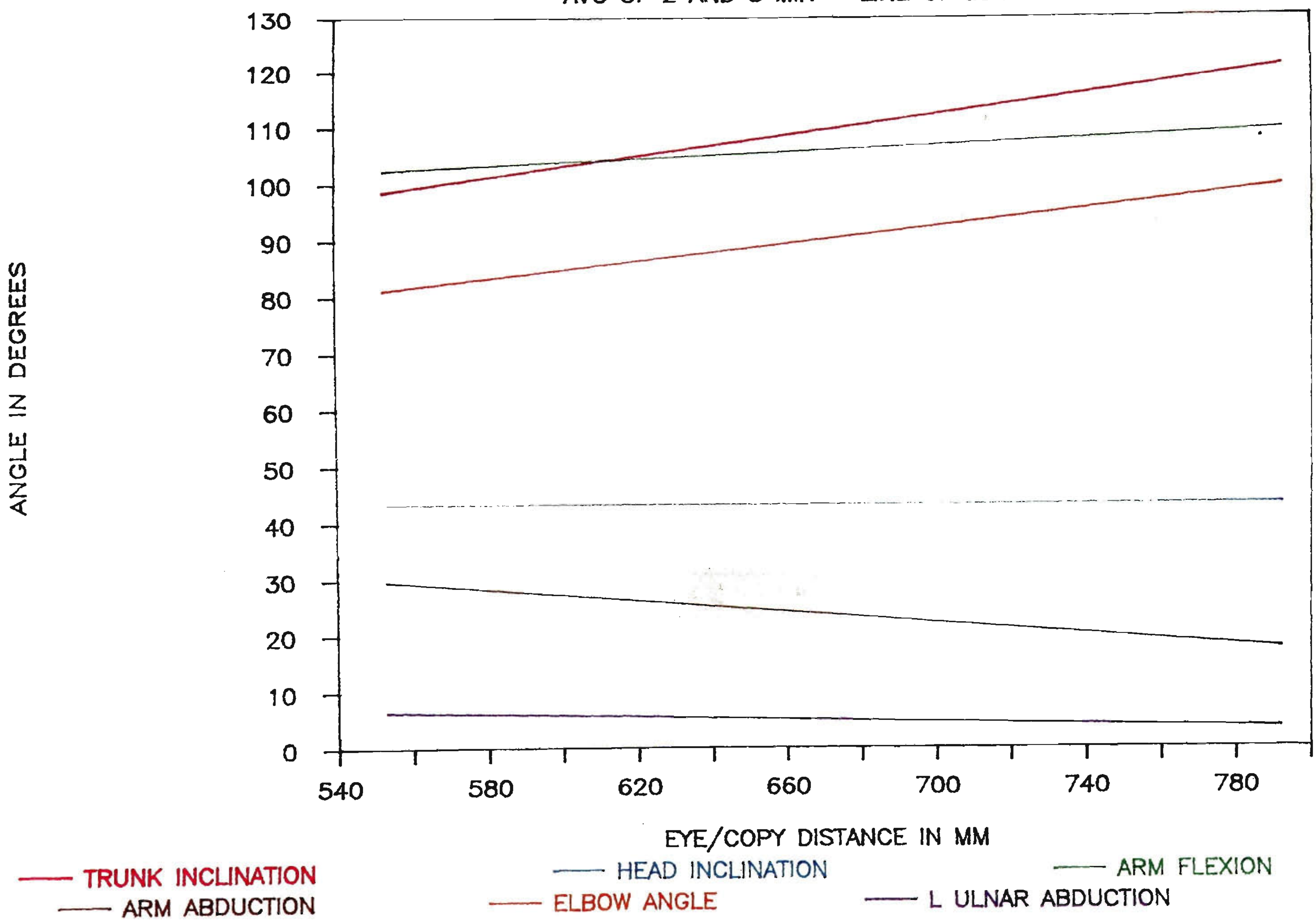

ACROM/KYBD RELATIONSHIPS — GROUP A
AVERAGE OF 2 AND 8 MIN MEASUREMENTS
ANGLE IN DEGREES
130
120
110
100
90
80
70
60
50
40
30
20
10
0
180
200
220
240
260
280
300
320
ACROMION/KEYBD DISTANCE IN MM
TRUNK INCLINATION
ARM ABDUCTION
HEAD INCLINATION
ELBOW ANGLE
ARM FLEXION
L ULNAR ABDUCTION

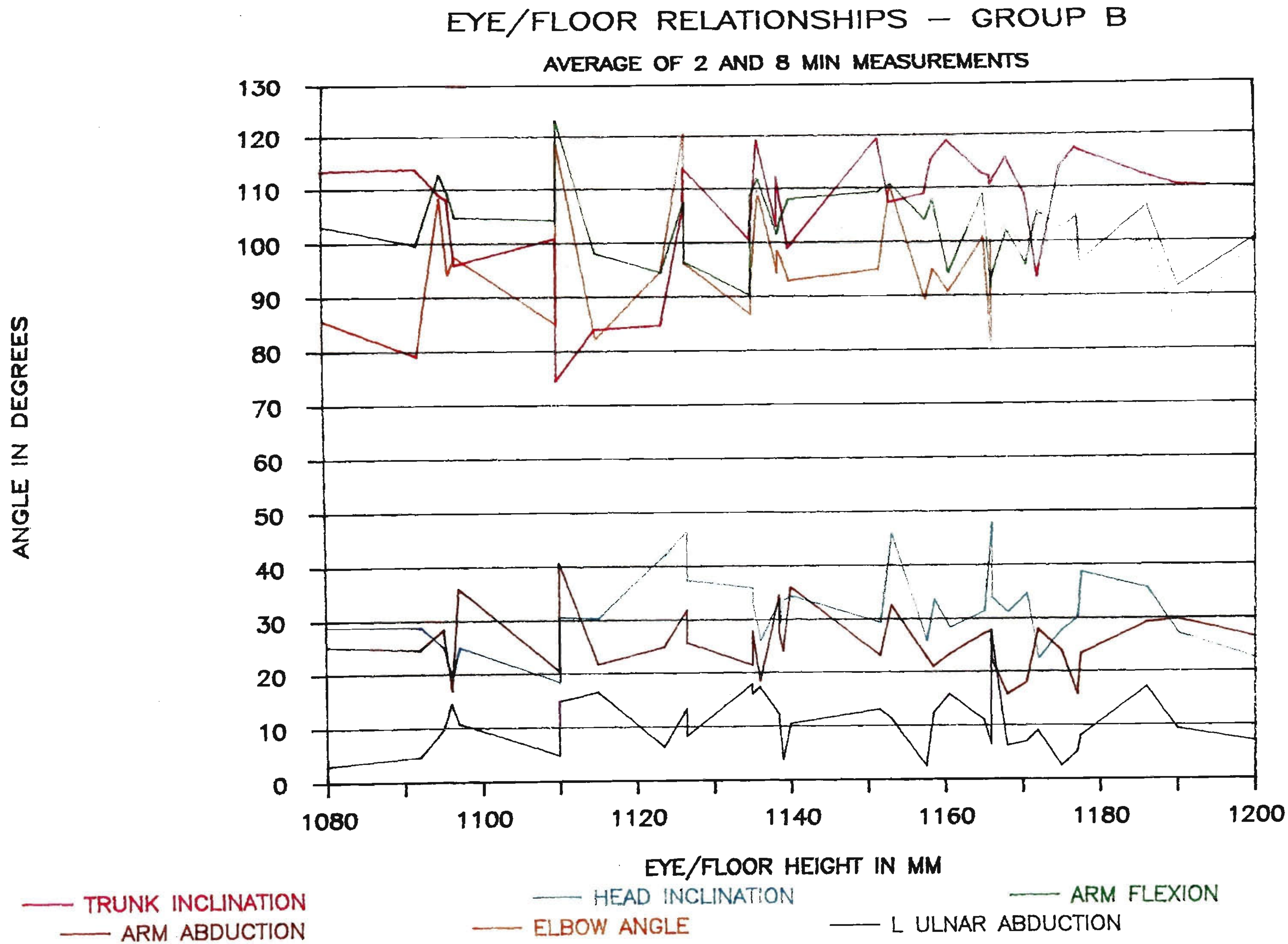

ACROM/KYBD RELATIONSHIPS – GROUP A
AVG OF 2 AND 8 MIN – LINE OF BEST FIT
ANGLE IN DEGREES
130
120
110
100
90
80
70
60
50
40
30
20
10
0
180
200
220
240
260
280
300
320
ACROMION/KEYBD DISTANCE IN MM
TRUNK INCLINATION
ARM ABDUCTION
HEAD INCLINATION
ELBOW ANGLE
ARM FLEXION
L ULNAR ABDUCTION


EYE/COPY RELATIONSHIPS – GROUP A
AVERAGE OF 2 AND 8 MIN MEASUREMENTS
ANGLE IN DEGREES
130
120
110
100
90
80
70
60
50
40
30
20
10
0
540
580
620
660
700
740
780
EYE/COPY DISTANCE IN MM
TRUNK INCLINATION
HEAD INCLINATION
ARM FLEXION
ARM ABDUCTION
ELBOW ANGLE
L ULNAR ABDUCTION

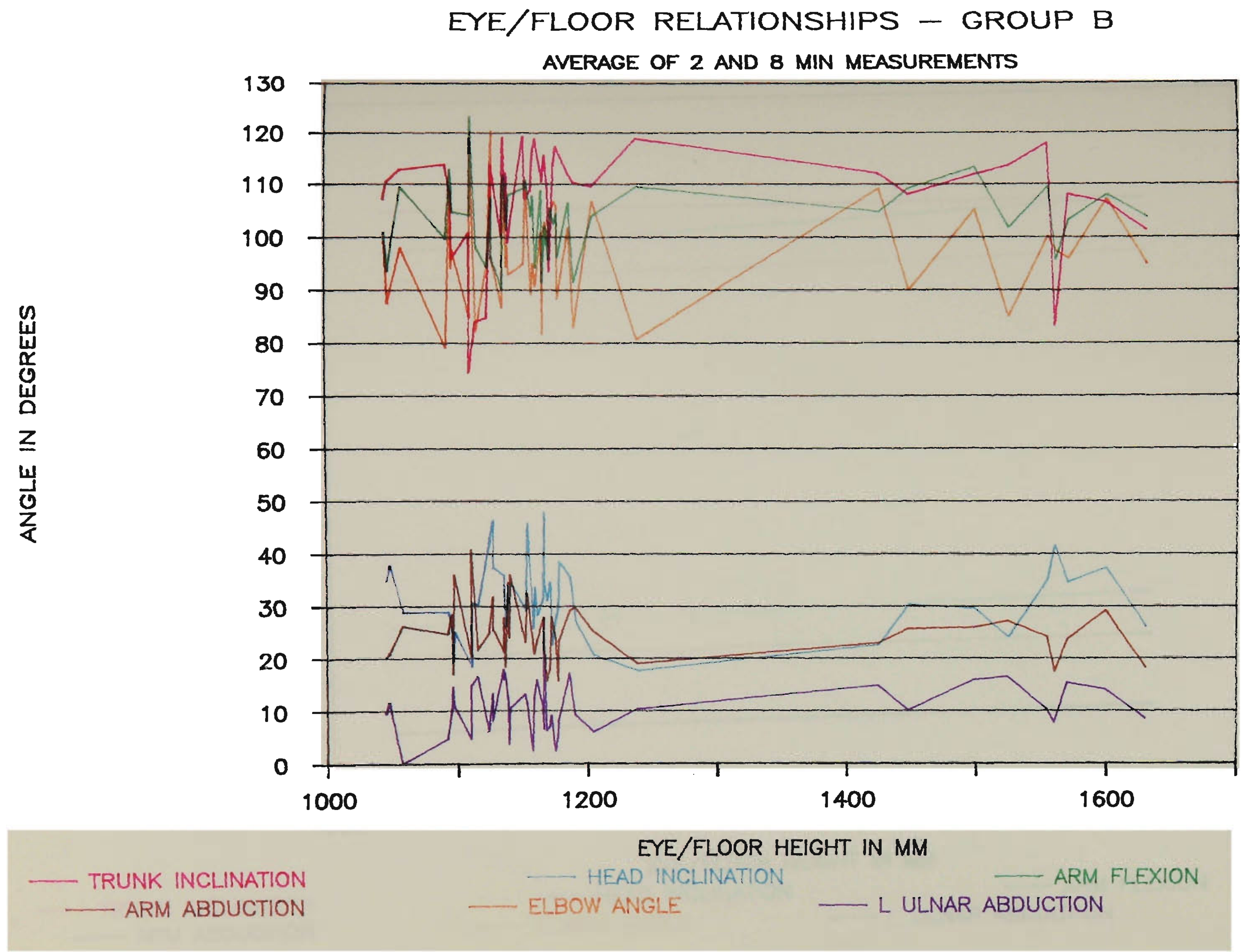
EYE/COPY RELATIONSHIPS – GROUP A

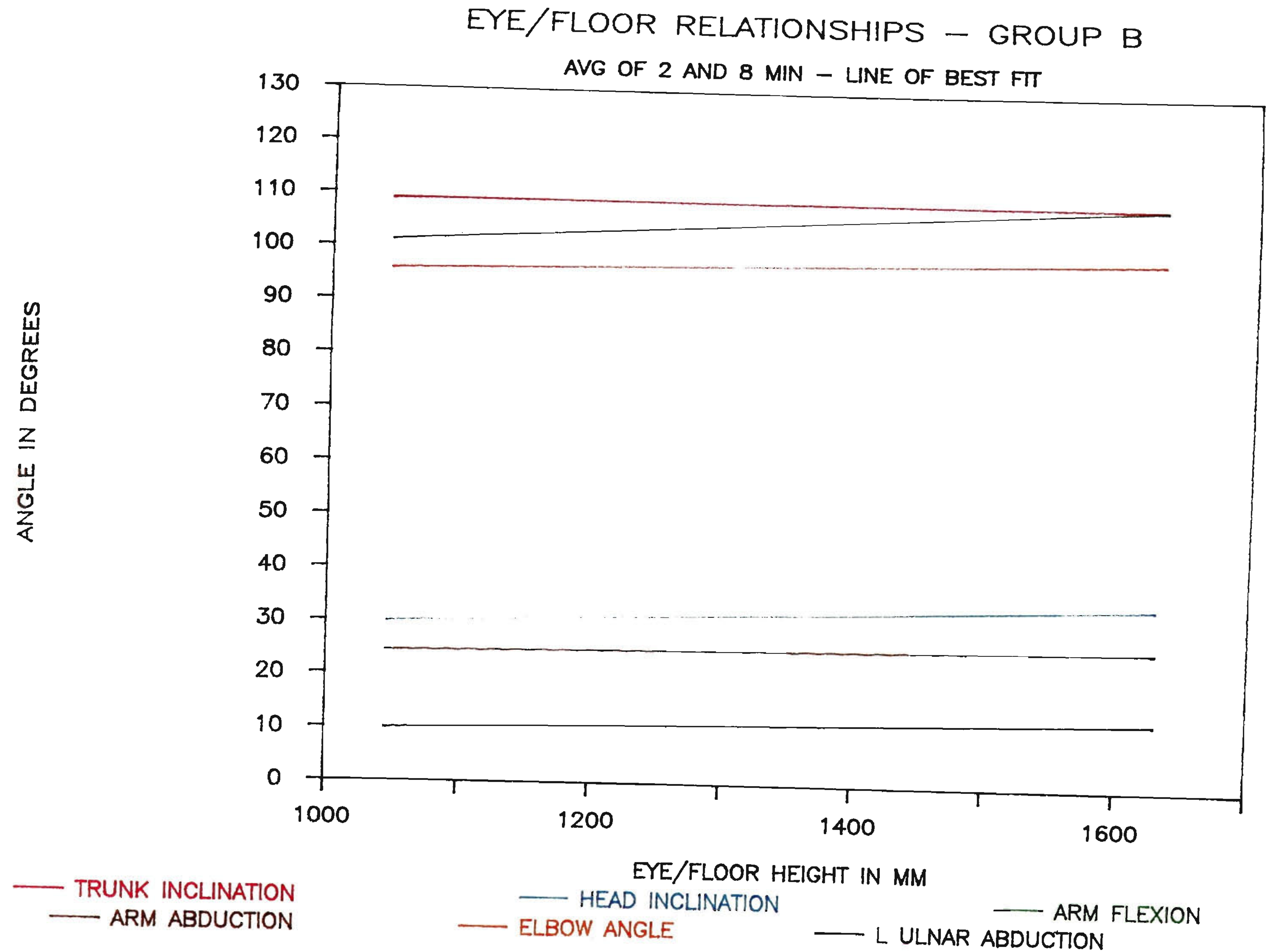
AVG OF 2 AND 8 MIN – LINE OF BEST FIT

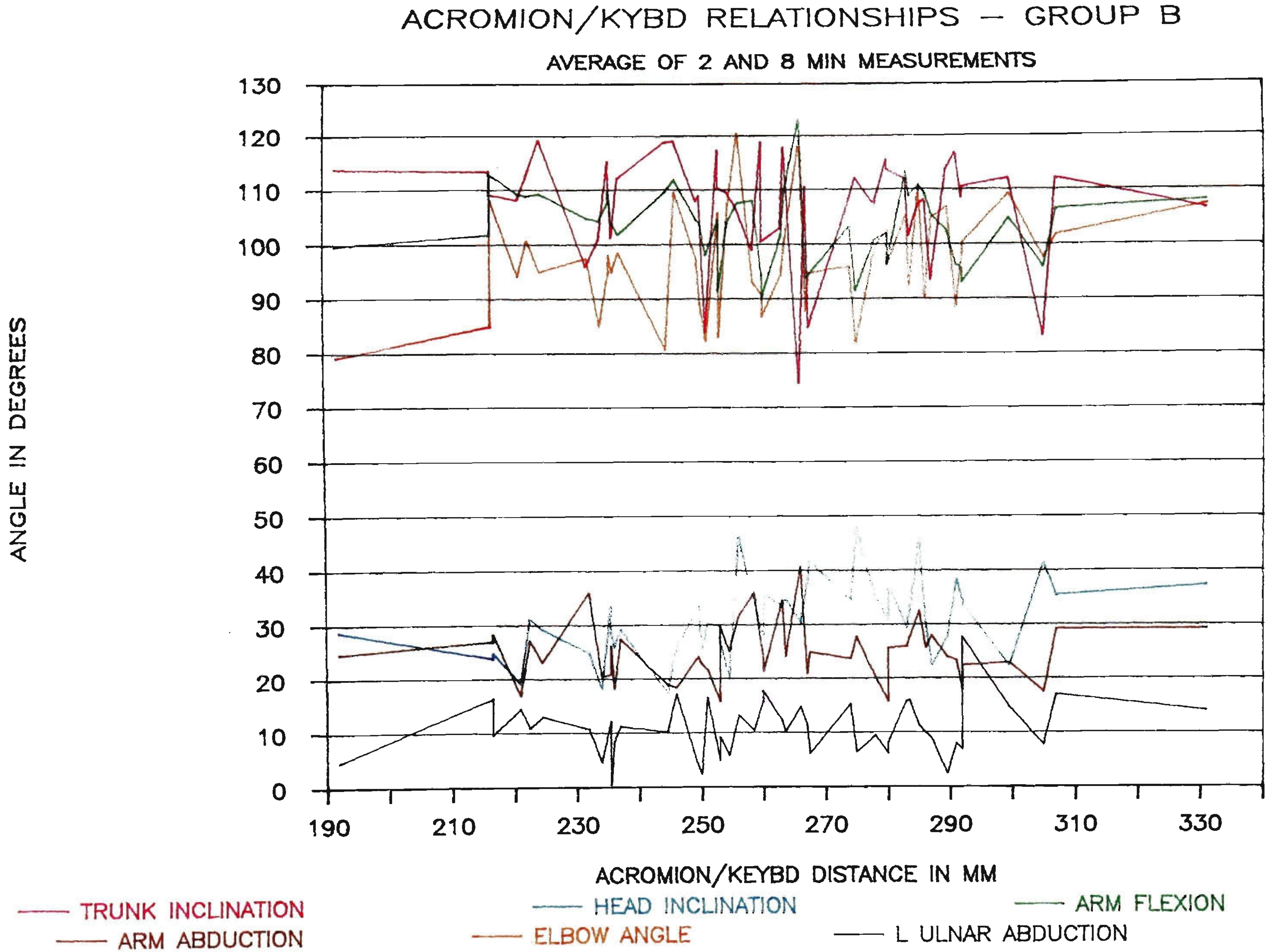


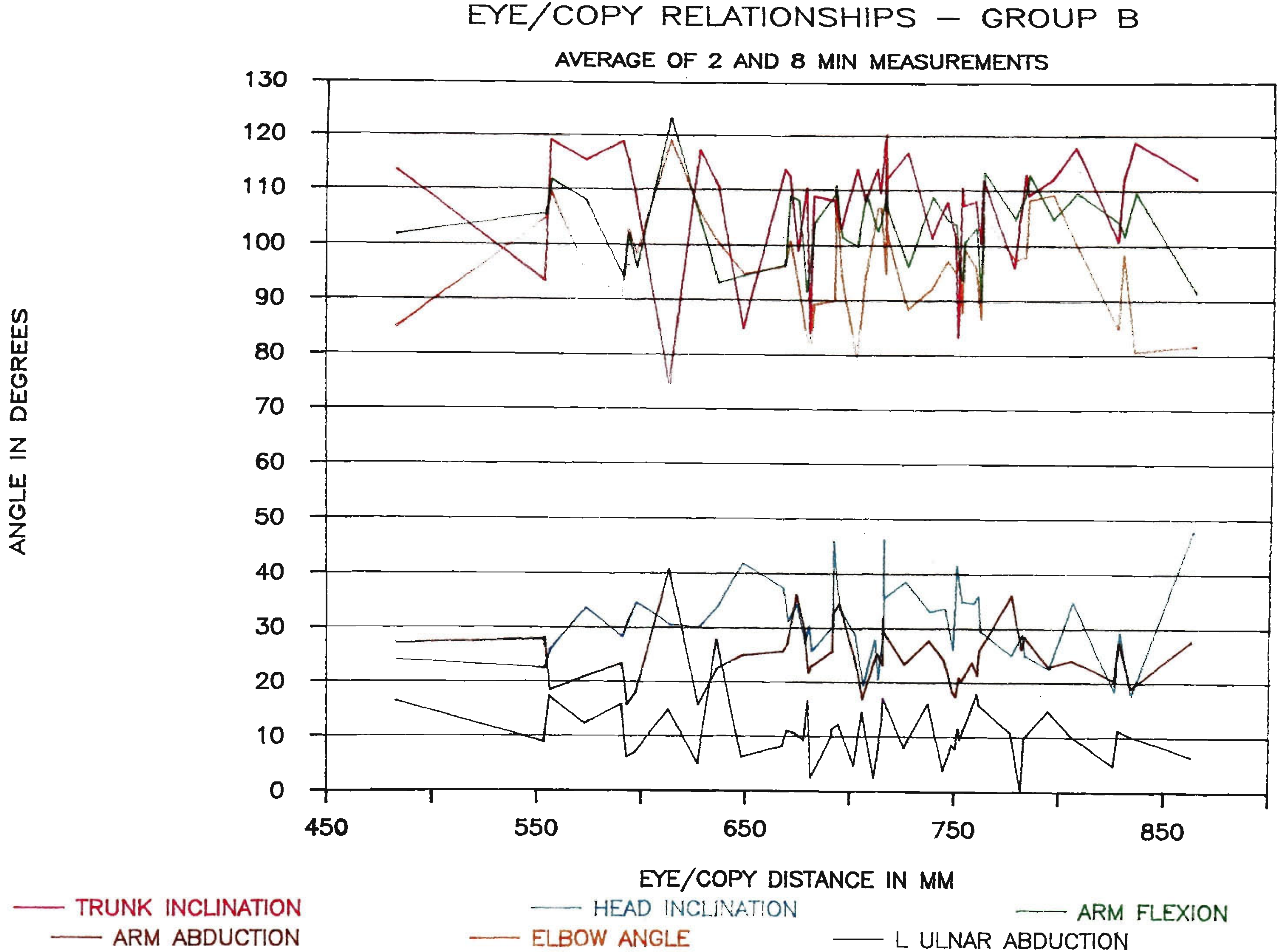


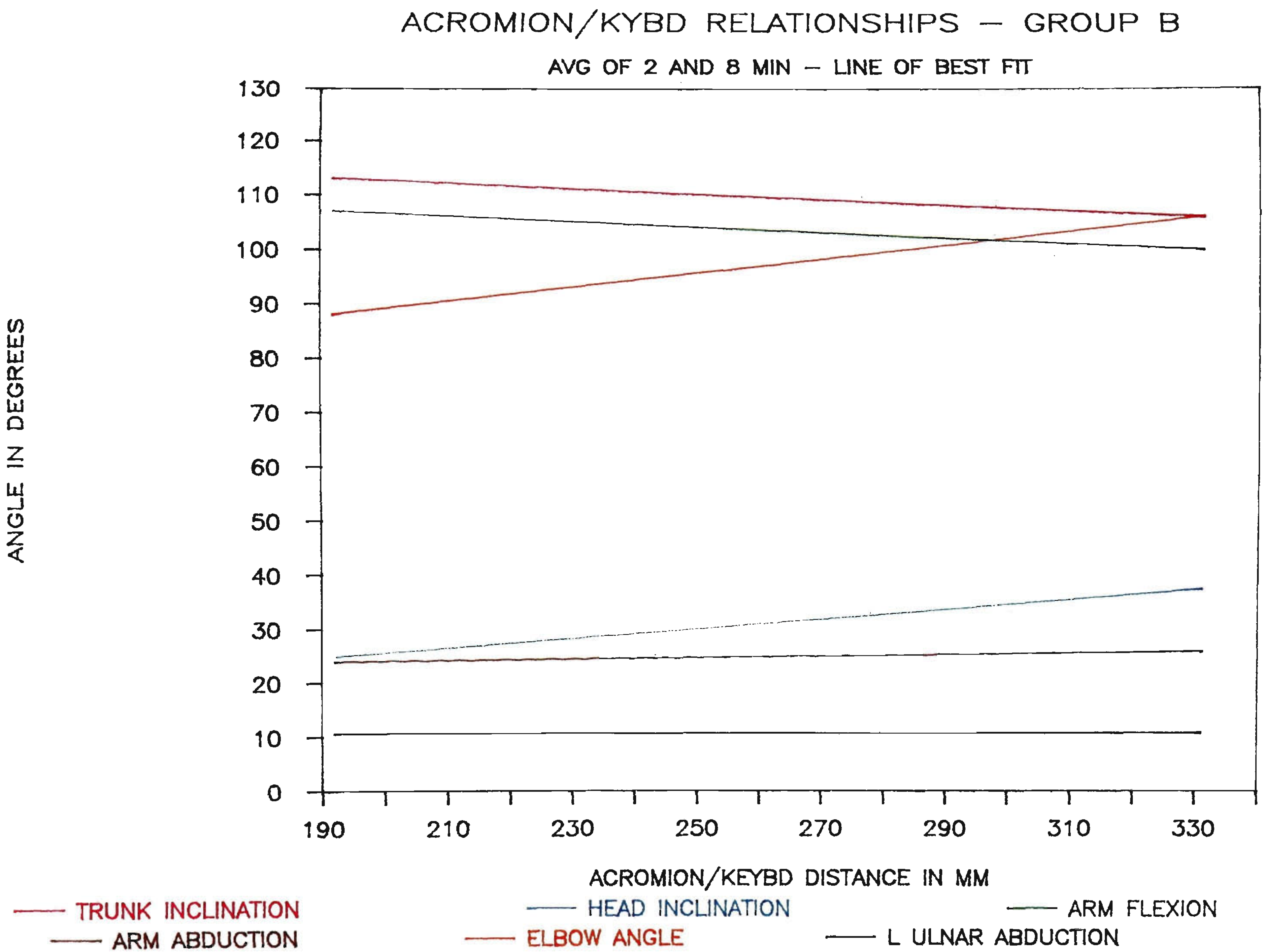
EYE/FLOOR RELATIONSHIPS – GROUP B
AVERAGE OF 2 AND 8 MIN MEASUREMENTS
ANGLE IN DEGREES
130
120
110
100
90
80
70
60
50
40
30
20
10
0
1080
1100
1120
1140
1160
1180
1200
EYE/FLOOR HEIGHT IN MM
TRUNK INCLINATION
ARM ABDUCTION
HEAD INCLINATION
ELBOW ANGLE
ARM FLEXION
L ULNAR ABDUCTION

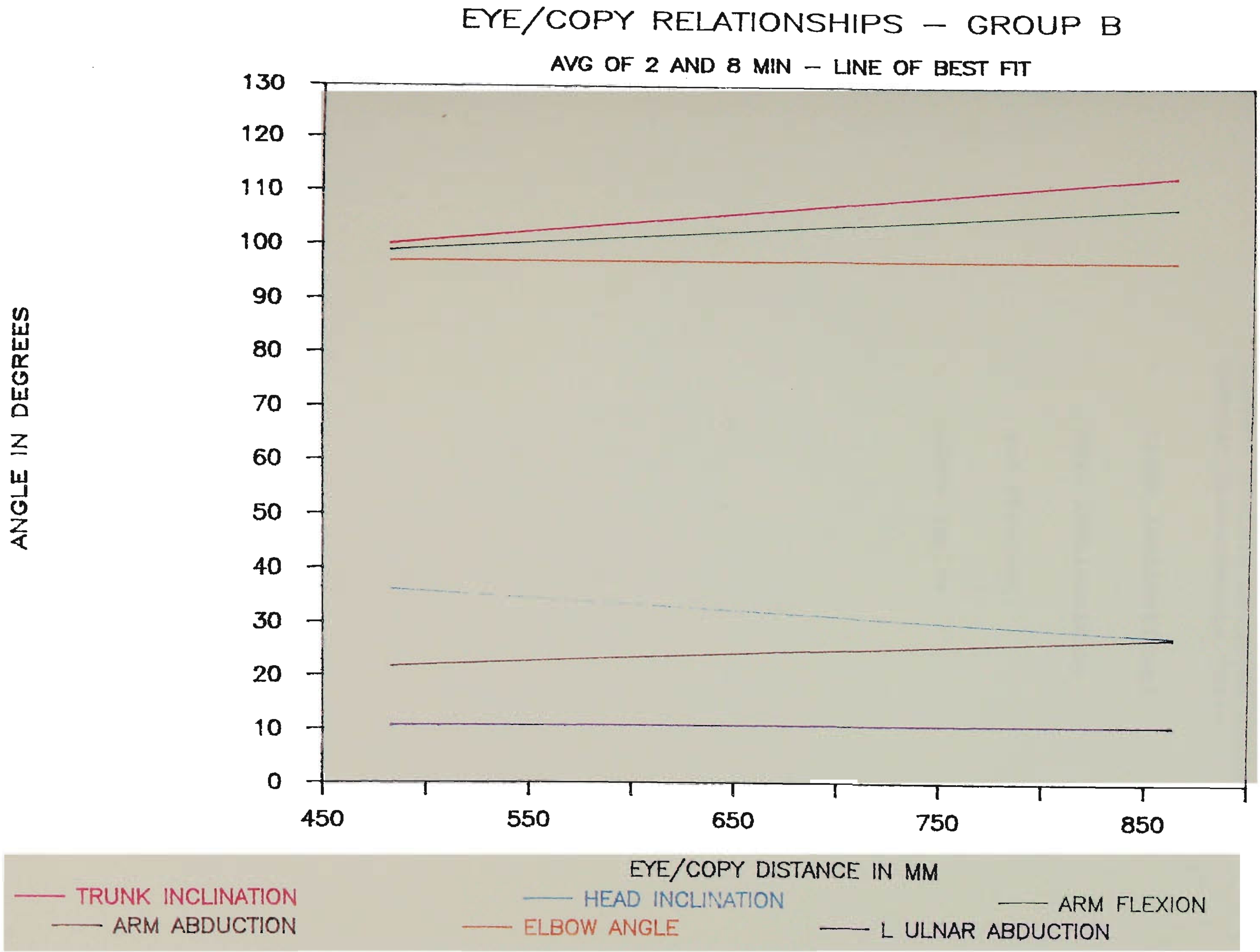

EYE/FLOOR RELATIONSHIPS — GROUP B
AVERAGE OF 2 AND 8 MIN MEASUREMENTS
ANGLE IN DEGREES
130
120
110
100
90
80
70
60
50
40
30
20
10
0
1000
1200
1400
1600
EYE/FLOOR HEIGHT IN MM
TRUNK INCLINATION
ARM ABDUCTION
HEAD INCLINATION
ELBOW ANGLE
ARM FLEXION
L ULNAR ABDUCTION


EYE/FLOOR RELATIONSHIPS — GROUP B
AVG OF 2 AND 8 MIN — LINE OF BEST FIT
ANGLE IN DEGREES
130
120
110
100
90
80
70
60
50
40
30
20
10
0
1000
1200
1400
1600
EYE/FLOOR HEIGHT IN MM
TRUNK INCLINATION
ARM ABDUCTION
HEAD INCLINATION
ELBOW ANGLE
ARM FLEXION
L ULNAR ABDUCTION

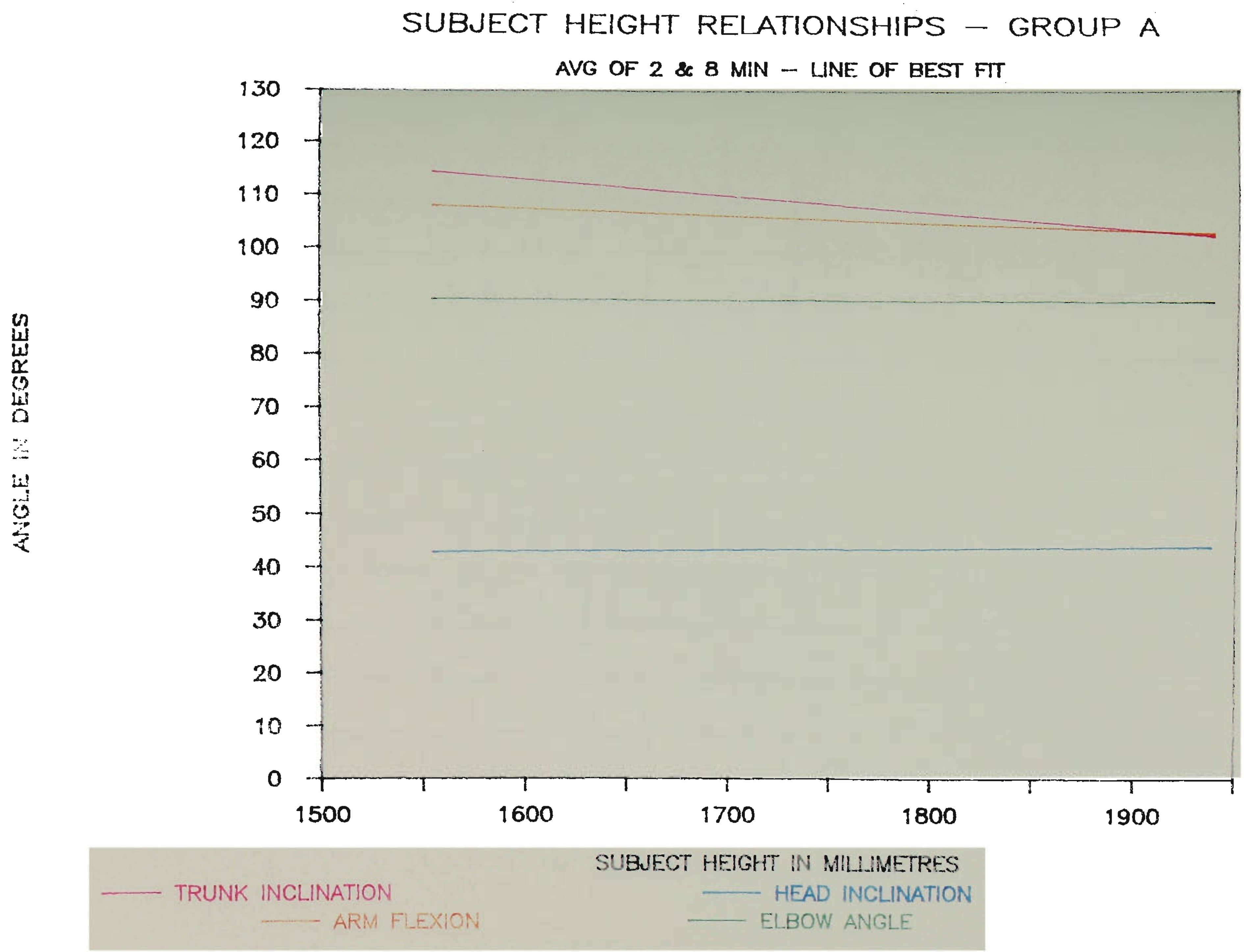

ACROMION/KYBD RELATIONSHIPS — GROUP B
AVERAGE OF 2 AND 8 MIN MEASUREMENTS
ANGLE IN DEGREES
130
120
110
100
90
80
70
60
50
40
30
20
10
0
190
210
230
250
270
290
310
330
ACROMION/KEYBD DISTANCE IN MM
TRUNK INCLINATION
ARM ABDUCTION
HEAD INCLINATION
ELBOW ANGLE
ARM FLEXION
L ULNAR ABDUCTION


EYE/COPY RELATIONSHIPS – GROUP B
AVERAGE OF 2 AND 8 MIN MEASUREMENTS
ANGLE IN DEGREES
130
120
110
100
90
80
70
60
50
40
30
20
10
0
450
550
650
750
850
EYE/COPY DISTANCE IN MM
TRUNK INCLINATION
ARM ABDUCTION
HEAD INCLINATION
ELBOW ANGLE
ARM FLEXION
L ULNAR ABDUCTION


ACROMION/KYBD RELATIONSHIPS — GROUP B
AVG OF 2 AND 8 MIN — LINE OF BEST FIT
ANGLE IN DEGREES
130
120
110
100
90
80
70
60
50
40
30
20
10
0
190
210
230
250
270
290
310
330
ACROMION/KEYBD DISTANCE IN MM
TRUNK INCLINATION
HEAD INCLINATION
ARM FLEXION
ARM ABDUCTION
ELBOW ANGLE
L ULNAR ABDUCTION

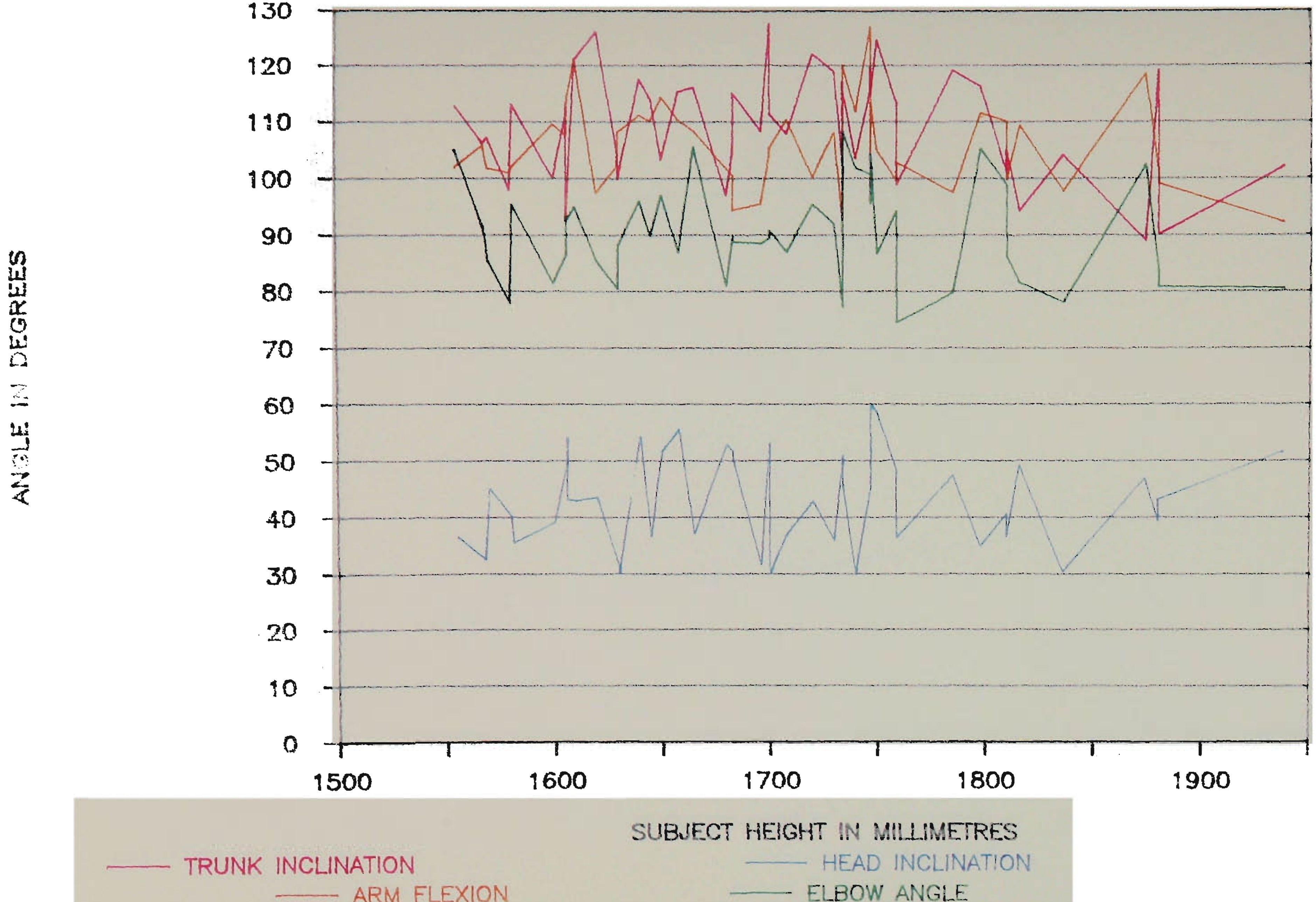

EYE/COPY RELATIONSHIPS — GROUP B
AVG OF 2 AND 8 MIN — LINE OF BEST FIT
ANGLE IN DEGREES
130
120
110
100
90
80
70
60
50
40
30
20
10
0
450
550
650
750
850
EYE/COPY DISTANCE IN MM
TRUNK INCLINATION
ARM ABDUCTION
HEAD INCLINATION
ELBOW ANGLE
ARM FLEXION
L ULNAR ABDUCTION

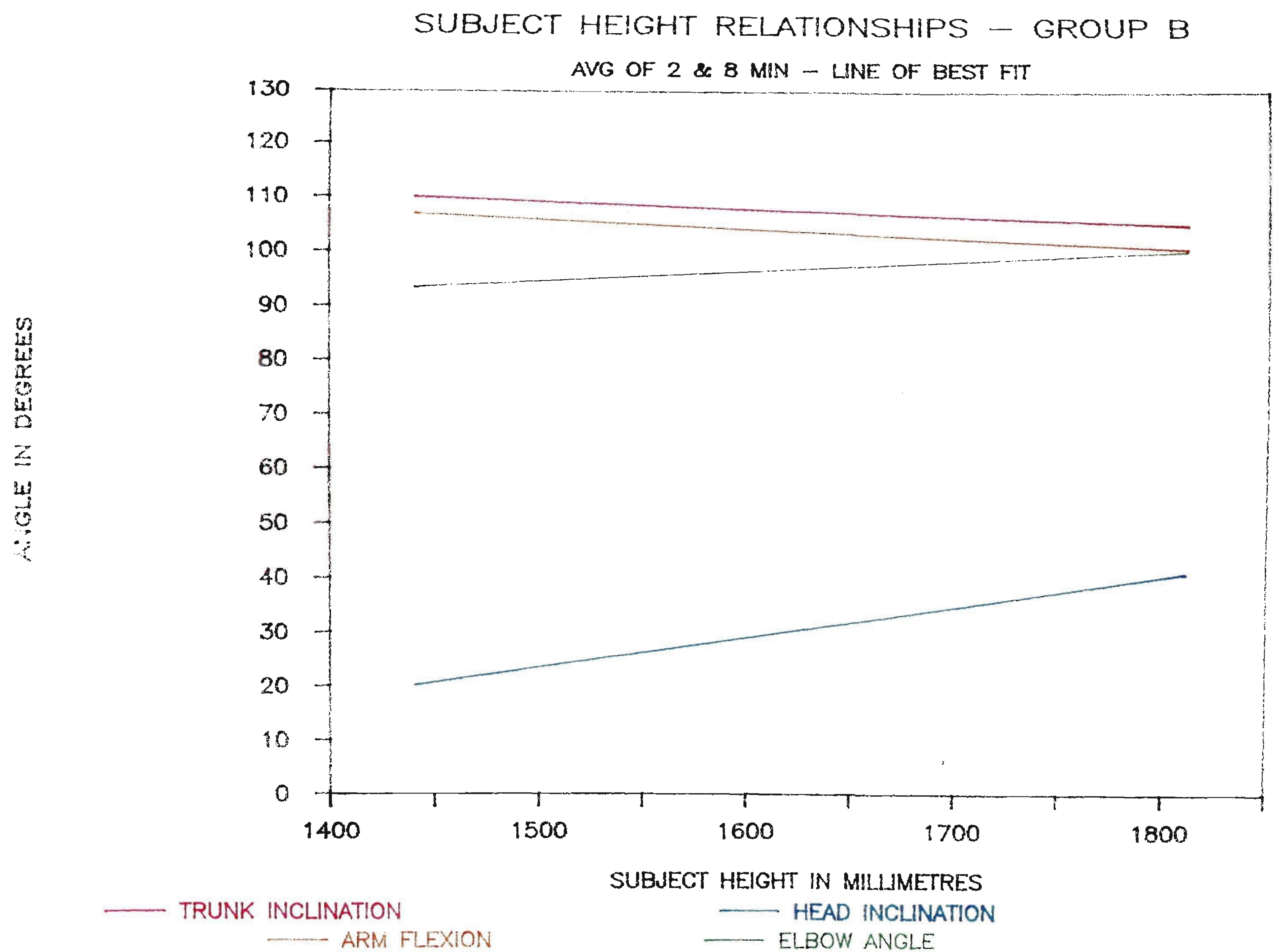
APPENDICES

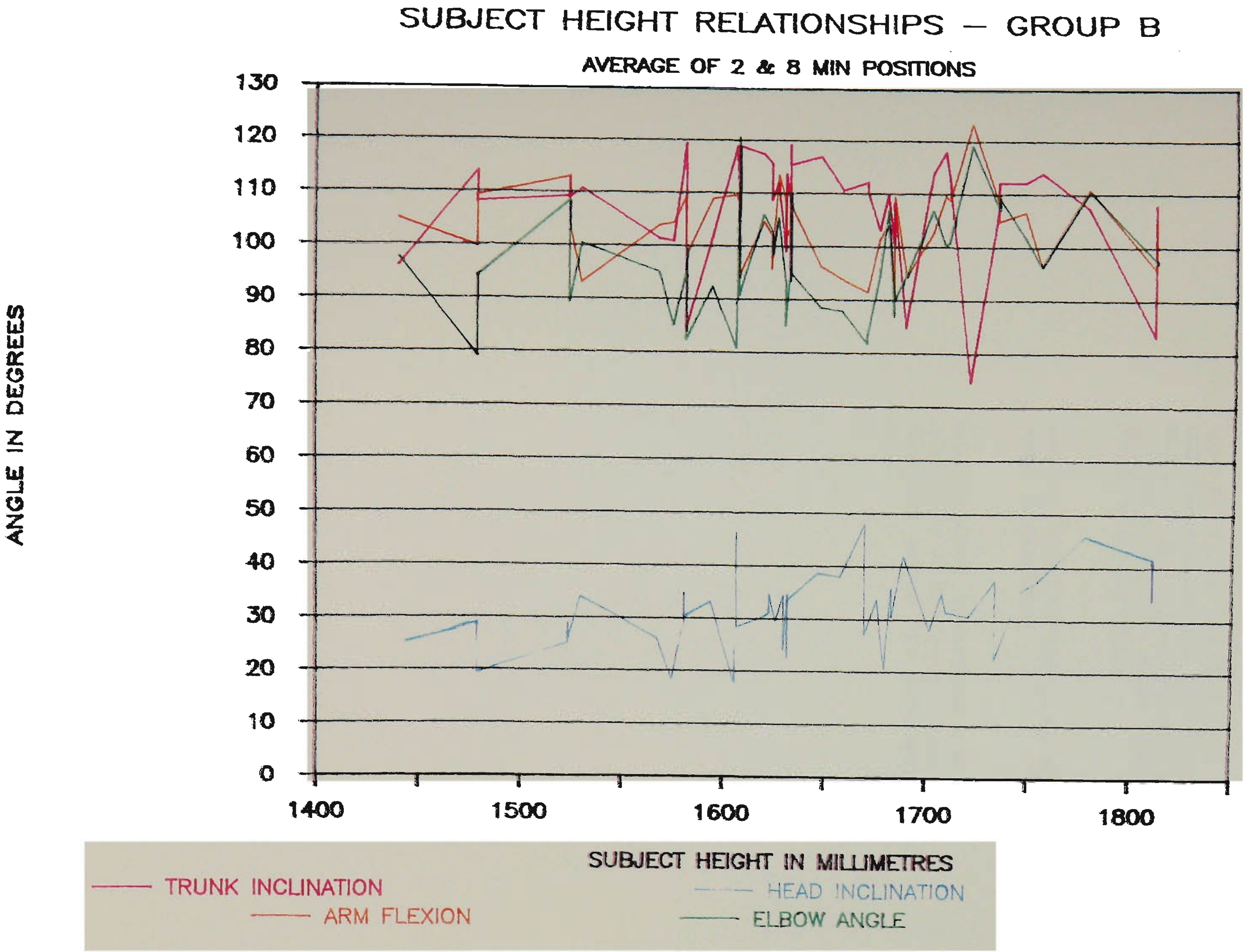

SUBJECT HEIGHT RELATIONSHIPS — GROUP A
AVG OF 2 & 8 MIN — LINE OF BEST FIT
ANGLE IN DEGREES
130
120
110
100
90
80
70
60
50
40
30
20
10
0
1500
1600
1700
1800
1900
SUBJECT HEIGHT IN MILLIMETRES
TRUNK INCLINATION
ARM FLEXION
HEAD INCLINATION
ELBOW ANGLE

SUBJECT HEIGHT RELATIONSHIPS — GROUP A

AVERAGE OF 2 & 8 MIN POSITIONS




SUBJECT HEIGHT RELATIONSHIPS – GROUP B
AVG OF 2 & 8 MIN – LINE OF BEST FIT
ANGLE IN DEGREES
130
120
110
100
90
80
70
60
50
40
30
20
10
0
1400
1500
1600
1700
1800
SUBJECT HEIGHT IN MILLIMETRES
TRUNK INCLINATION
ARM FLEXION
HEAD INCLINATION
ELBOW ANGLE


SUBJECT HEIGHT RELATIONSHIPS — GROUP B
AVERAGE OF 2 & 8 MIN POSITIONS
ANGLE IN DEGREES
130
120
110
100
90
80
70
60
50
40
30
20
10
0
1400
1500
1600
1700
1800
SUBJECT HEIGHT IN MILLIMETRES
TRUNK INCLINATION
ARM FLEXION
HEAD INCLINATION
ELBOW ANGLE

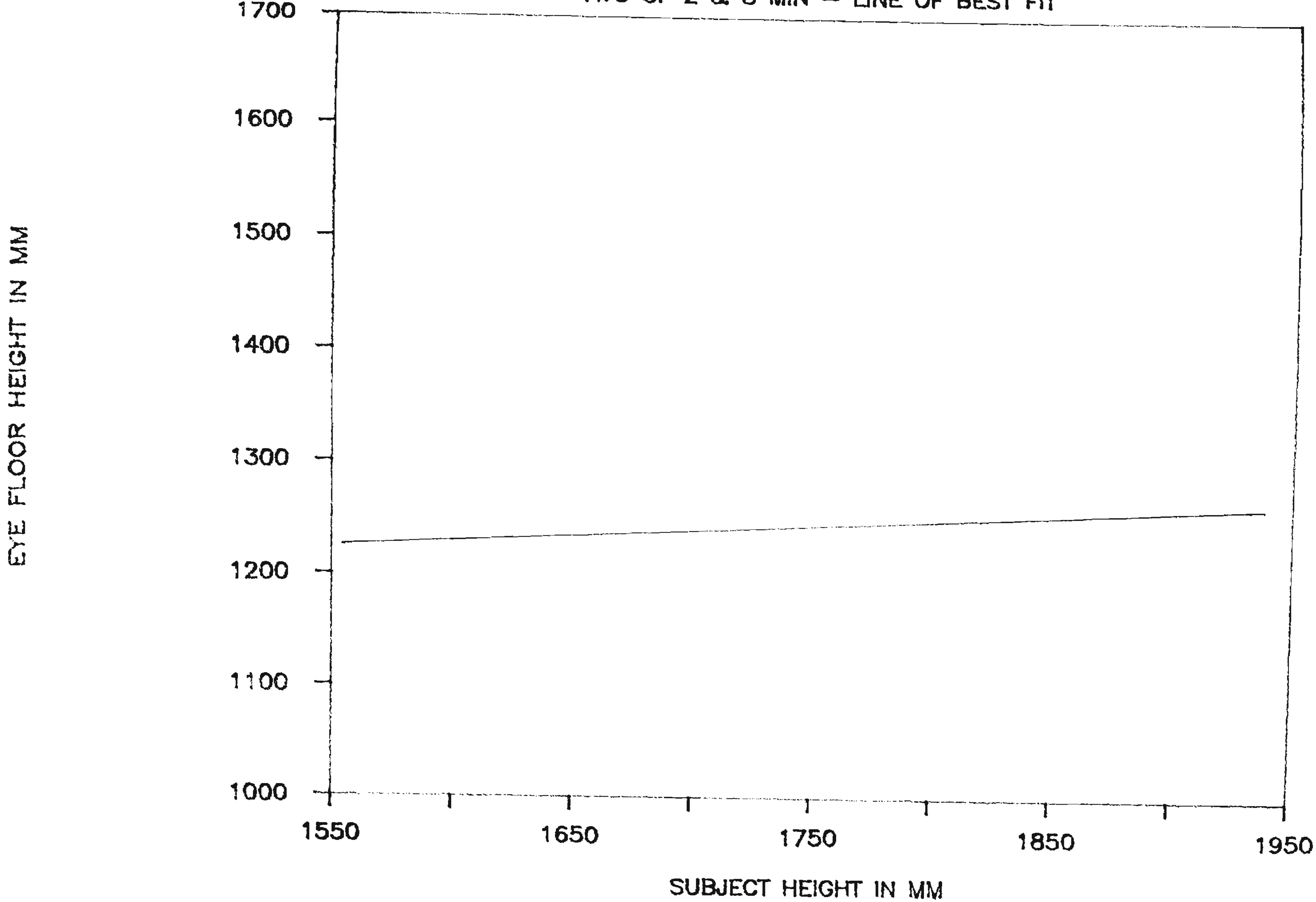
APPENDICES

APPENDIX F - Separate Relationship Graphs Including "Line of Best Fit" Projections for:-

- eye to floor heights and shoulder acromion process heights and shoulder acromion process heights above the keyboard home row;
- eye to floor heights an eye to copy distances;
- eye to copy distances and shoulder acromion process heights above the keyboard home row.

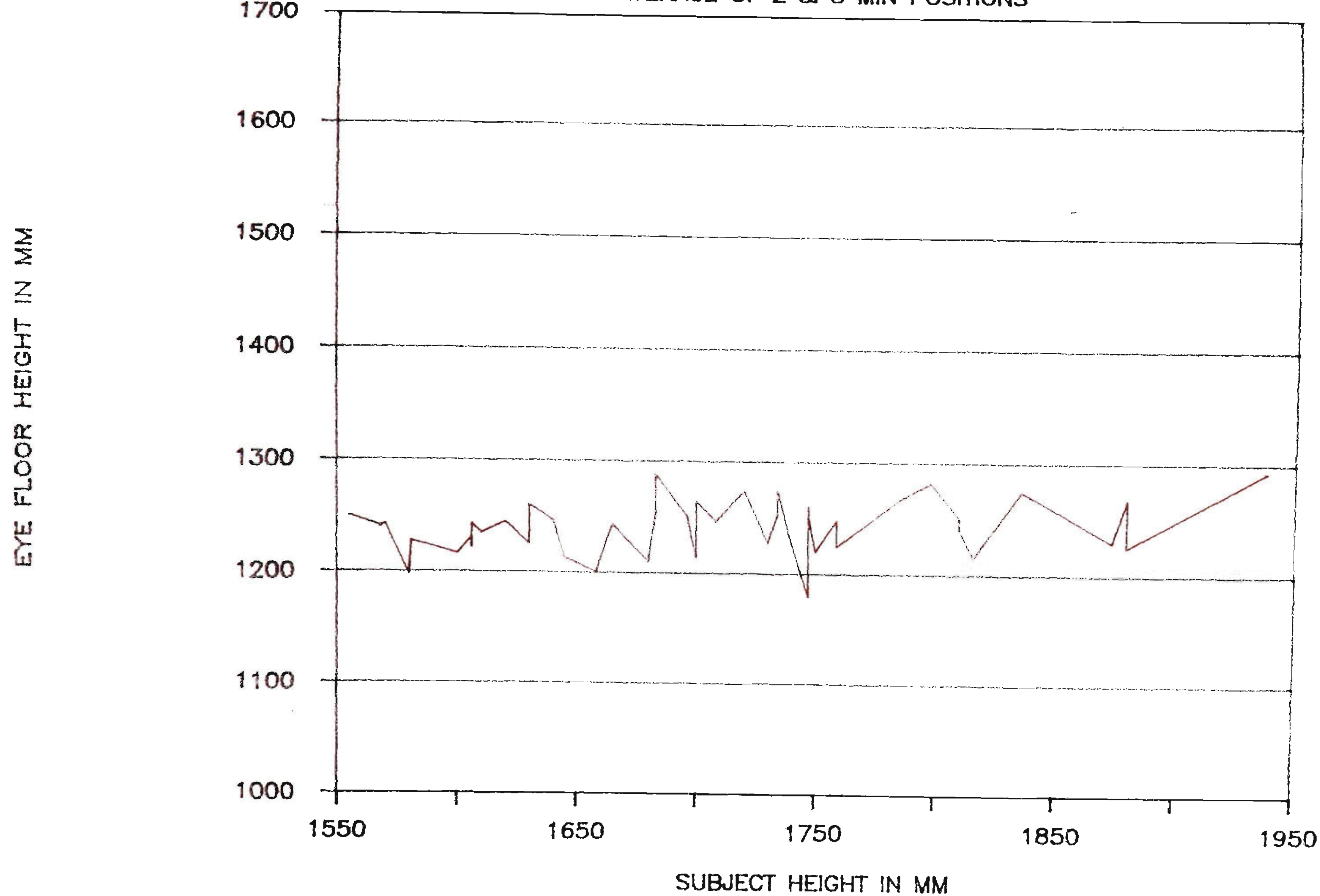
SUBJECT HGT v EYE FLOOR HGT — GROUP A

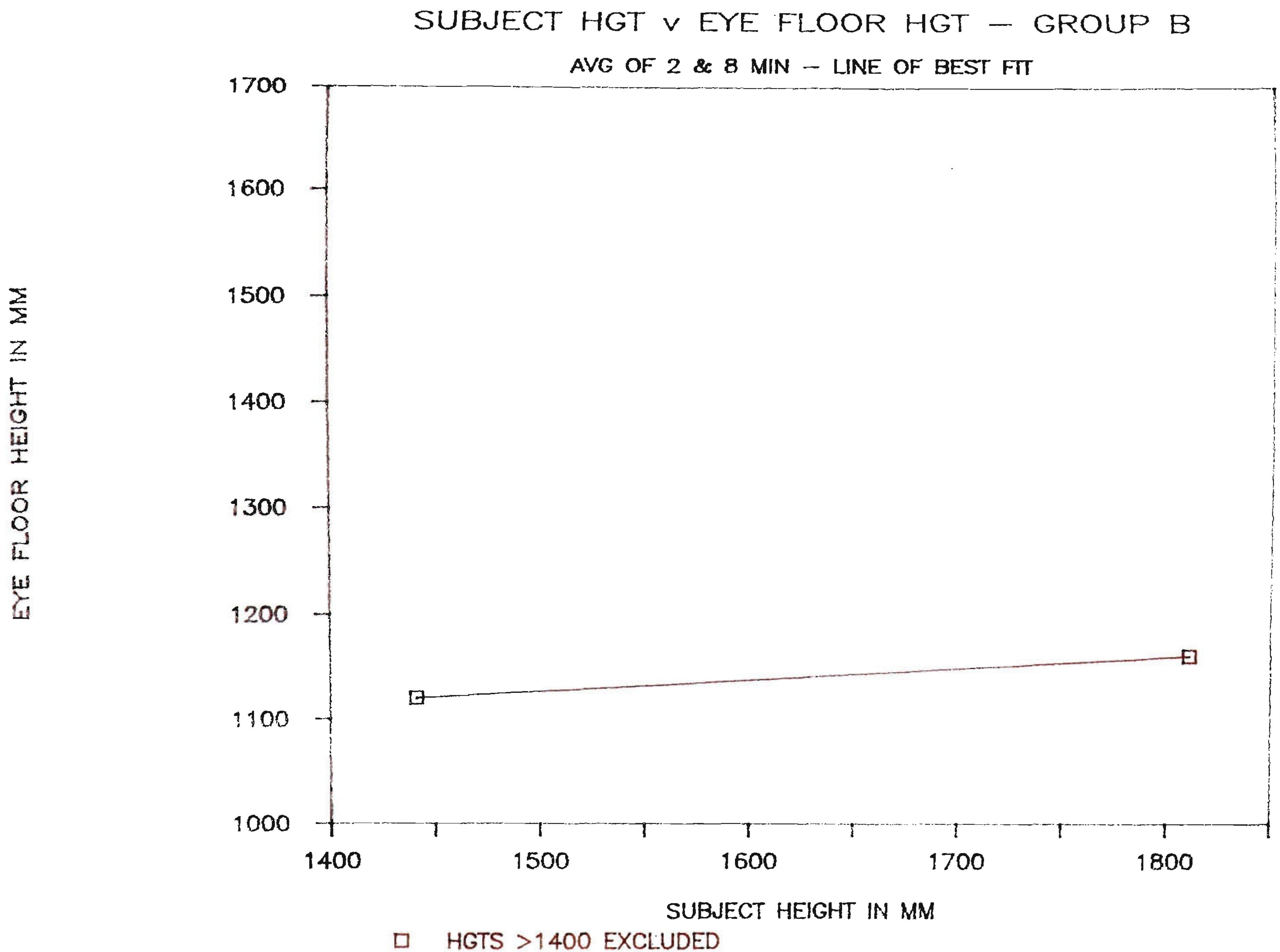
AVG OF 2 & 8 MIN — LINE OF BEST FIT



SUBJECT HGT v EYE FLOOR HGT – GROUP A

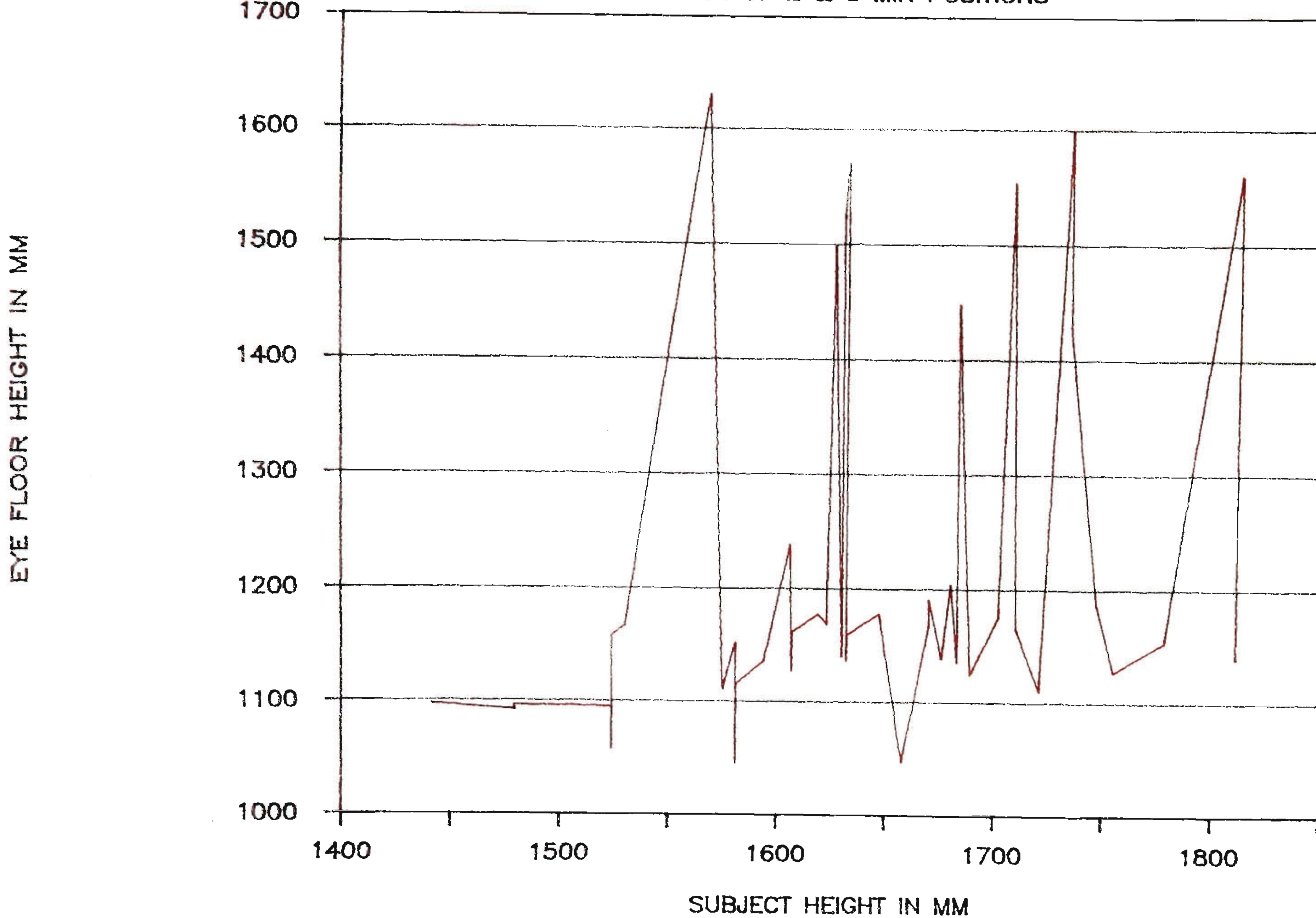
AVERAGE OF 2 & 8 MIN POSITIONS




SUBJECT HGT v EYE FLOOR HGT — GROUP B
AVG OF 2 & 8 MIN — LINE OF BEST FIT
EYE FLOOR HEIGHT IN MM
1700
1600
1500
1400
1300
1200
1100
1000
1400
1500
1600
1700
1800
SUBJECT HEIGHT IN MM
HGTS >1400 EXCLUDED

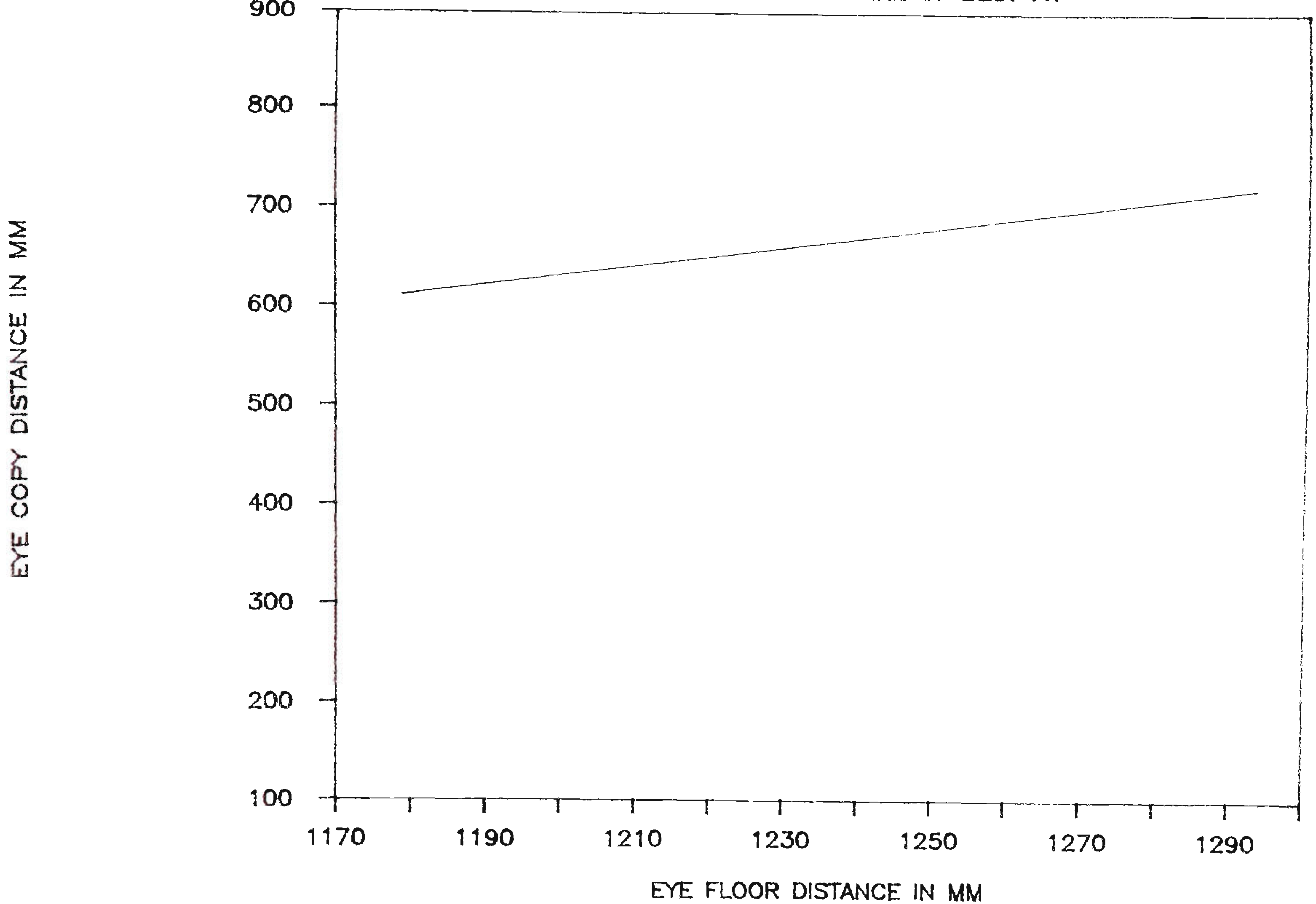
SUBJECT HGT v EYE FLOOR HGT — GROUP B

AVERAGE OF 2 & 8 MIN POSITIONS



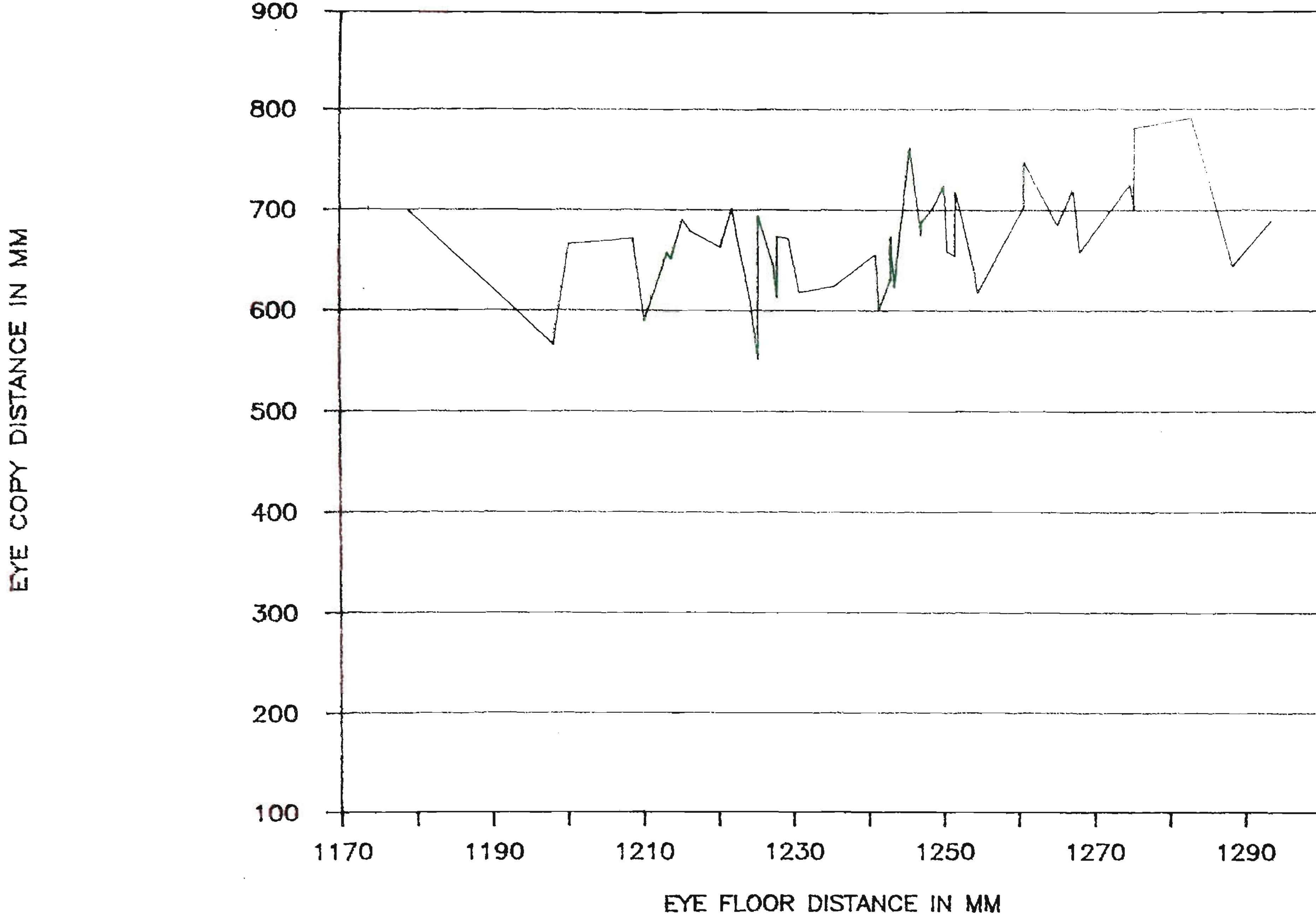
EYE FLOOR HGHT v EYE COPY DIST—GROUP A

AVG OF 2 & 8 MIN — LINE OF BEST FIT



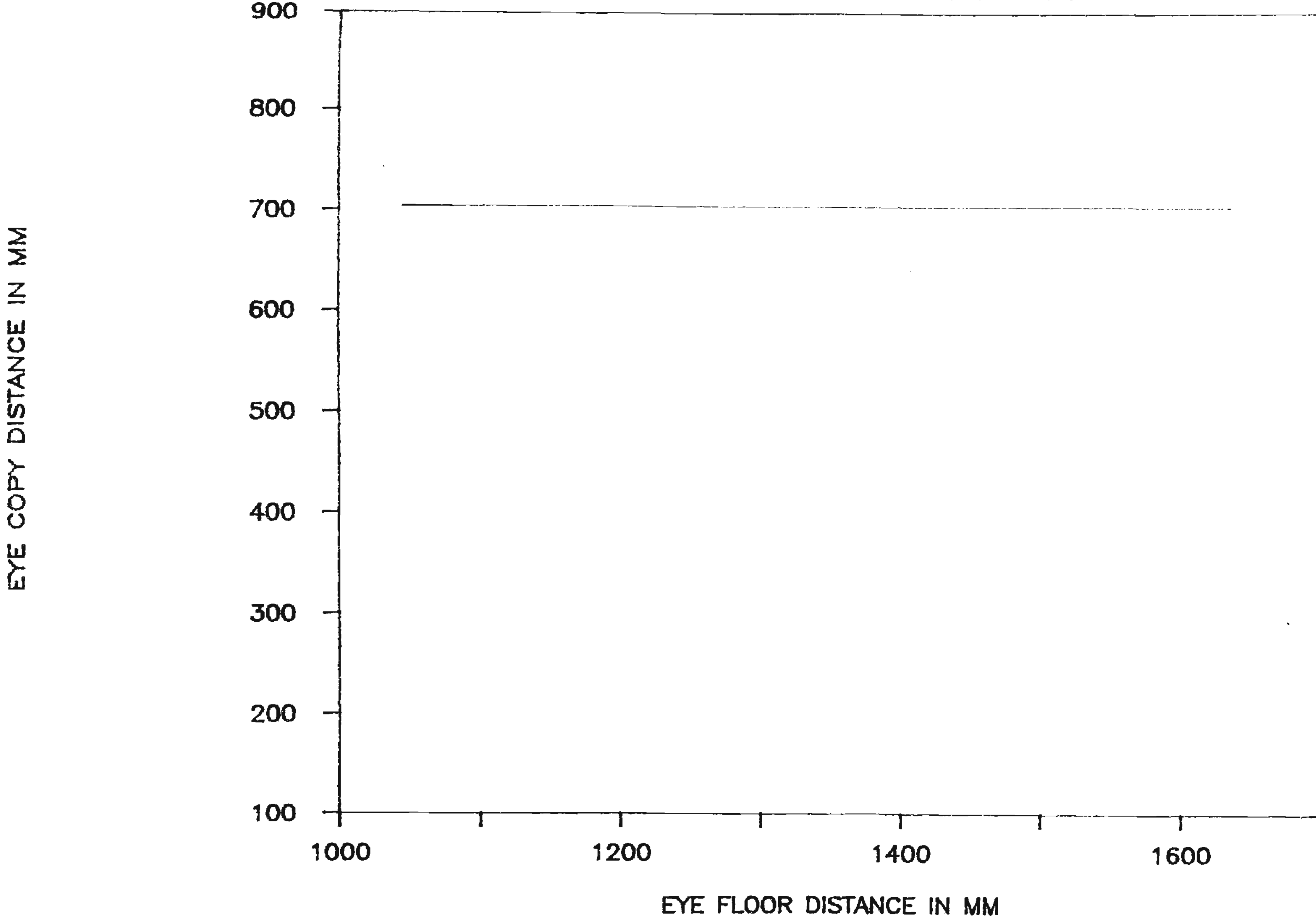
EYE FLOOR HGHT v EYE COPY DIST—GROUP A

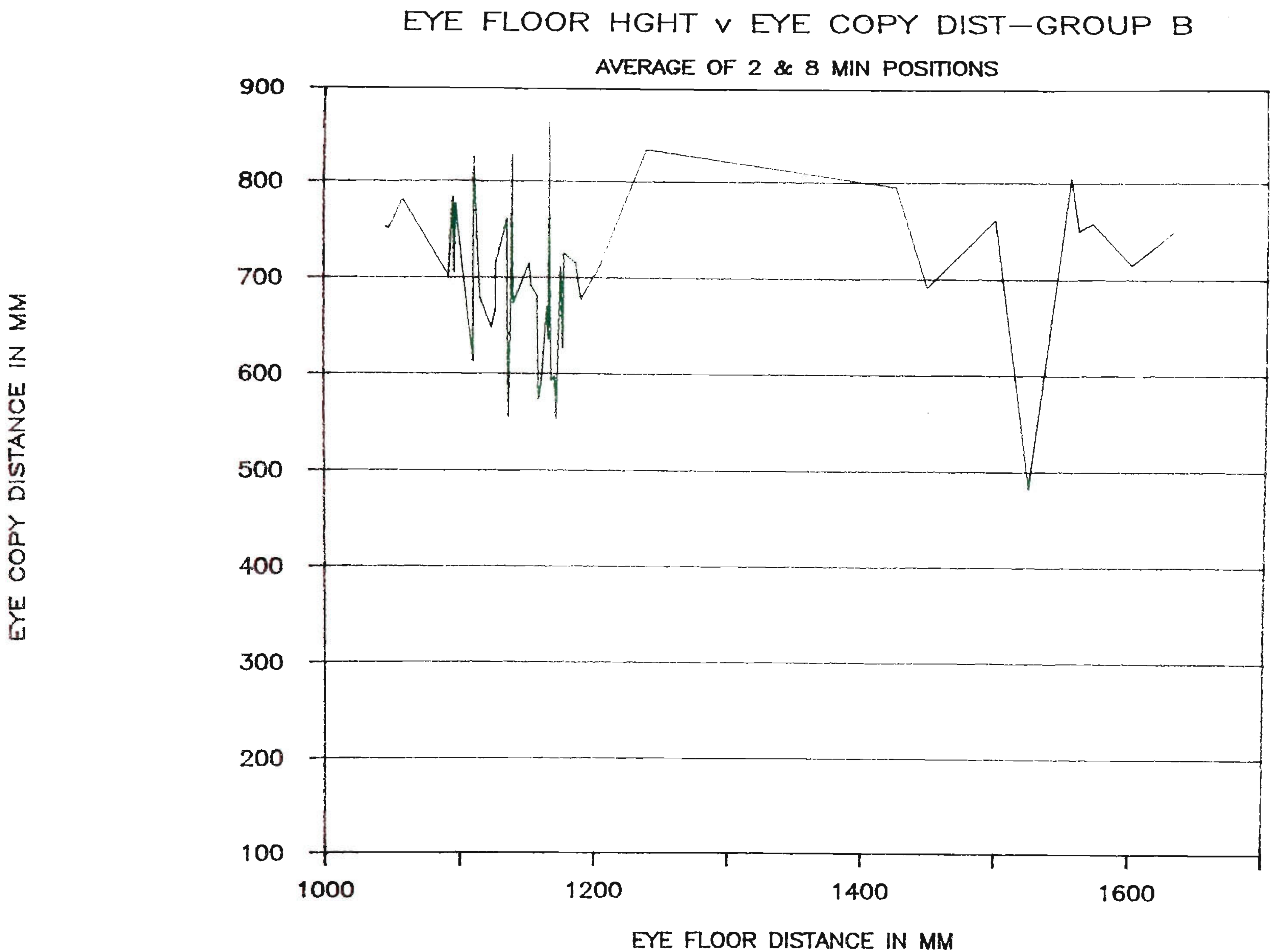
AVERAGE OF 2 & 8 MIN POSITIONS

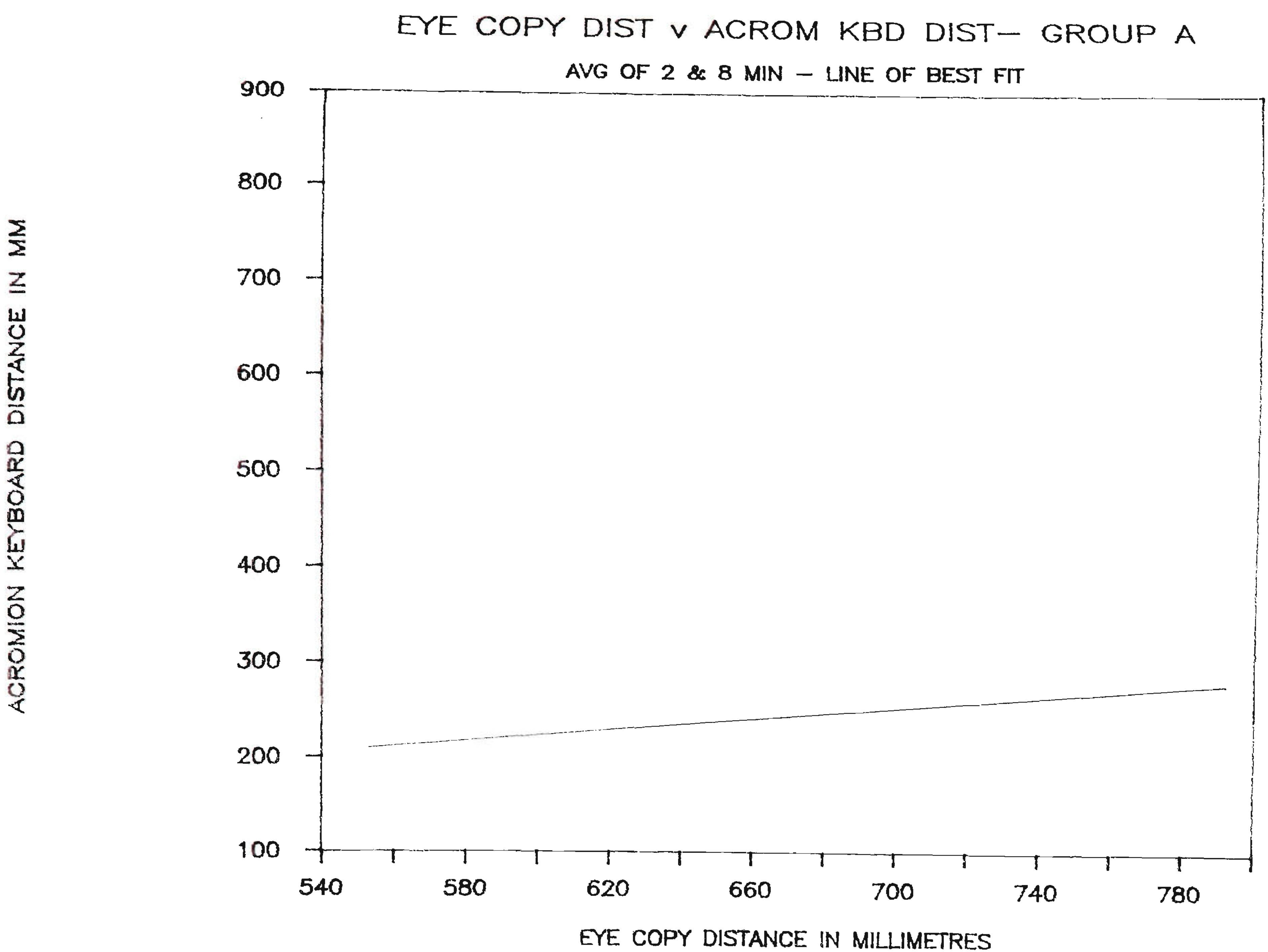


EYE FLOOR HGHT v EYE COPY DIST—GROUP B

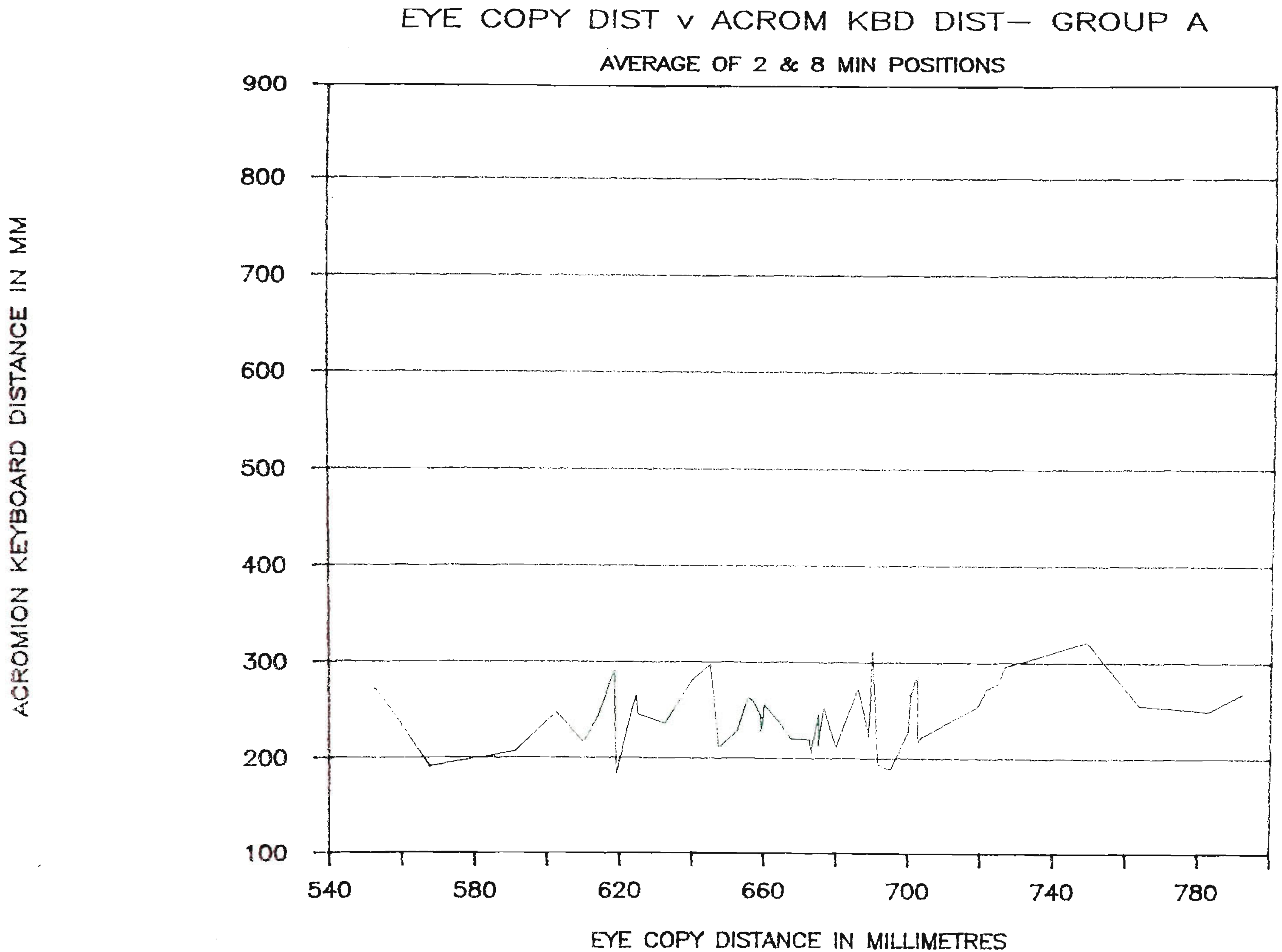
AVG OF 2 & 8 MIN — LINE OF BEST FIT



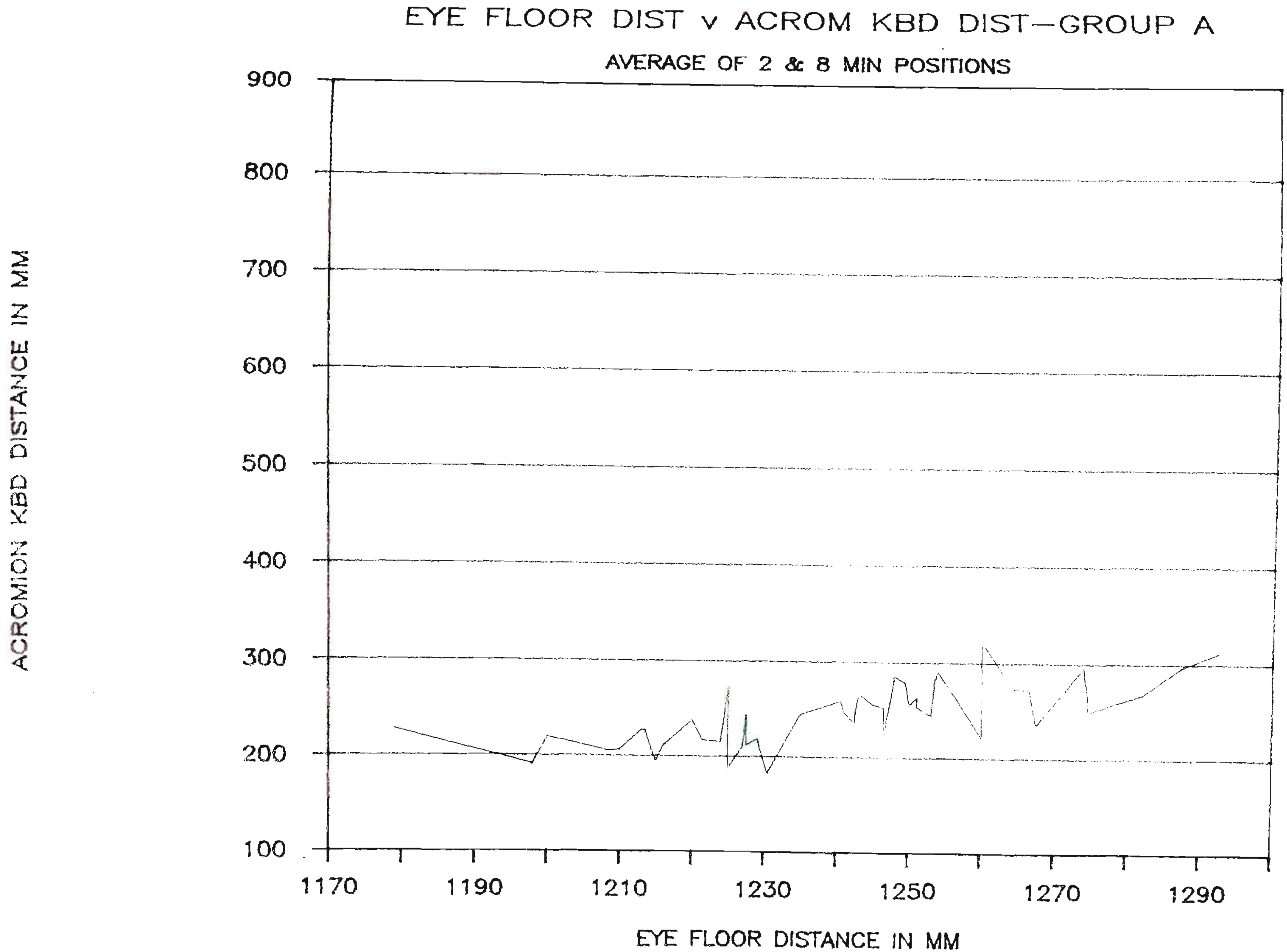

EYE FLOOR HGHT v EYE COPY DIST—GROUP B
AVERAGE OF 2 & 8 MIN POSITIONS
900
800
700
600
500
400
300
200
100
EYE COPY DISTANCE IN MM
1000
1200
1400
1600
EYE FLOOR DISTANCE IN MM

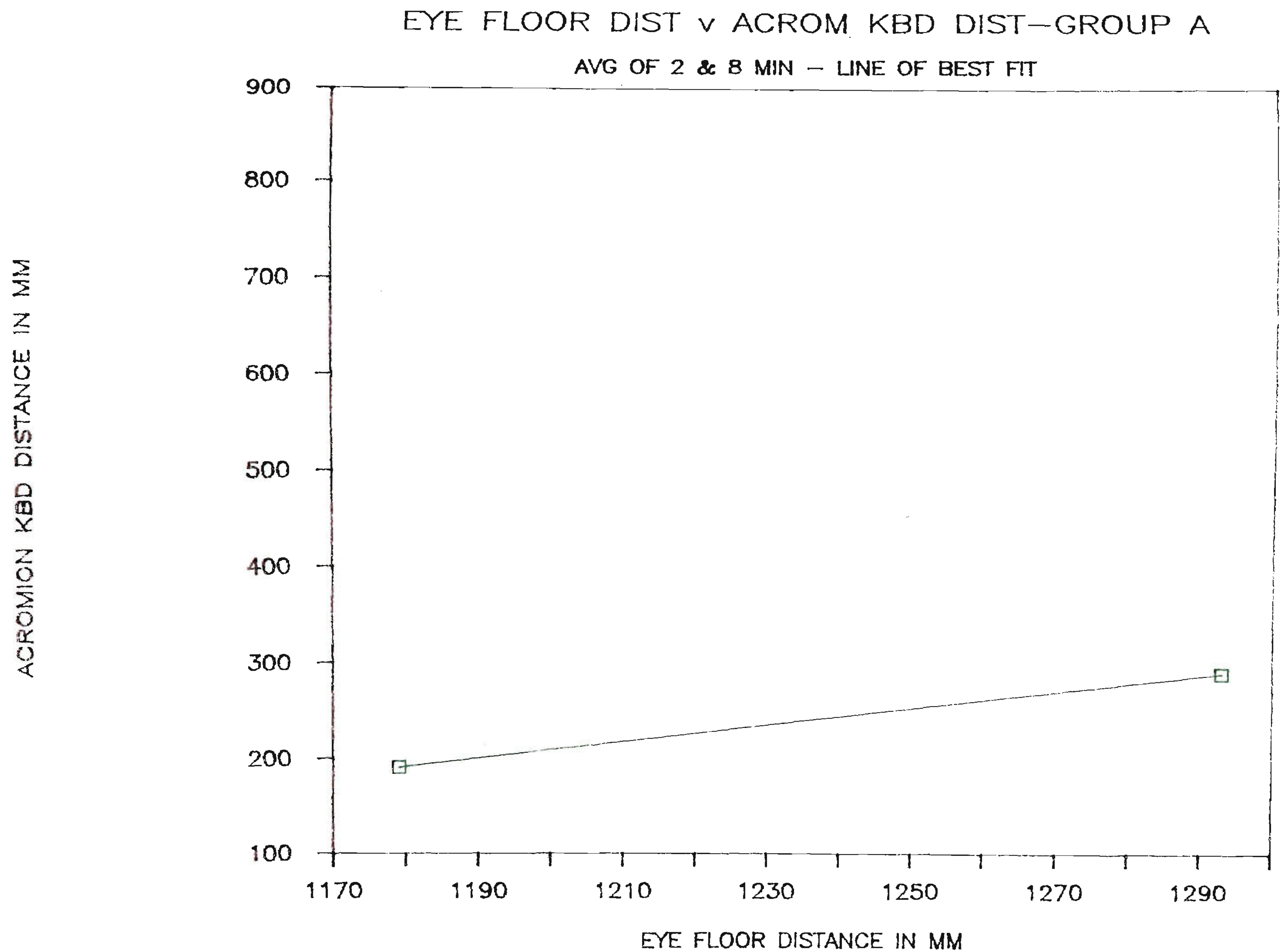


EYE COPY DIST v ACROM KBD DIST— GROUP A
AVG OF 2 & 8 MIN — LINE OF BEST FIT
ACROMION KEYBOARD DISTANCE IN MM
900
800
700
600
500
400
300
200
100
540
580
620
660
700
740
780
EYE COPY DISTANCE IN MILLIMETRES



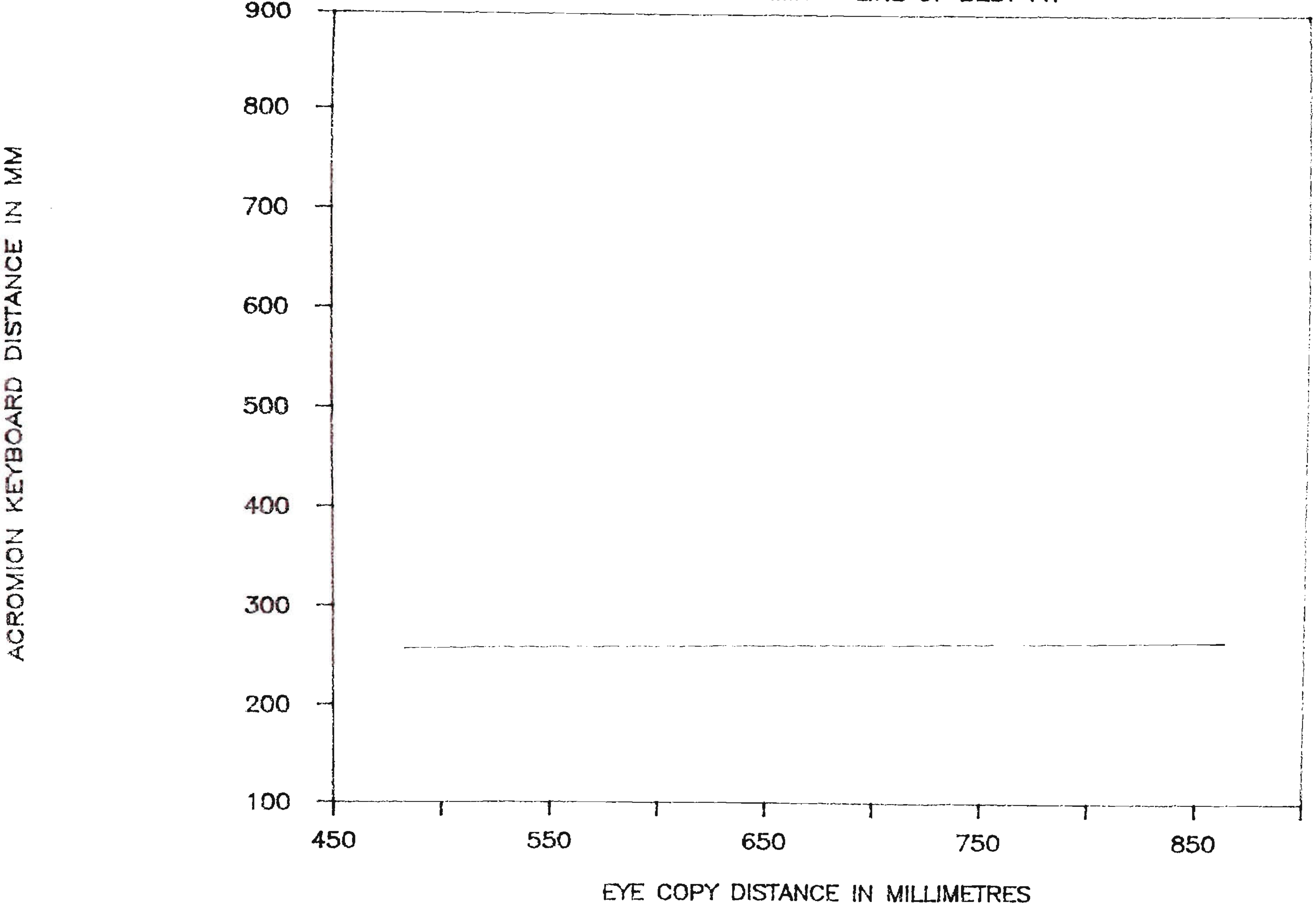
EYE COPY DIST v ACROM KBD DIST– GROUP A
AVERAGE OF 2 & 8 MIN POSITIONS
ACROMION KEYBOARD DISTANCE IN MM
900
800
700
600
500
400
300
200
100
540
580
620
660
700
740
780
EYE COPY DISTANCE IN MILLIMETRES


EYE FLOOR DIST v ACROM KBD DIST—GROUP A
AVERAGE OF 2 & 8 MIN POSITIONS
ACROMION KBD DISTANCE IN MM
900
800
700
600
500
400
300
200
100
1170
1190
1210
1230
1250
1270
1290
EYE FLOOR DISTANCE IN MM


EYE FLOOR DIST v ACROM KBD DIST–GROUP A
AVG OF 2 & 8 MIN – LINE OF BEST FIT
900
800
700
600
500
400
300
200
100
ACROMION KBD DISTANCE IN MM
1170
1190
1210
1230
1250
1270
1290
EYE FLOOR DISTANCE IN MM

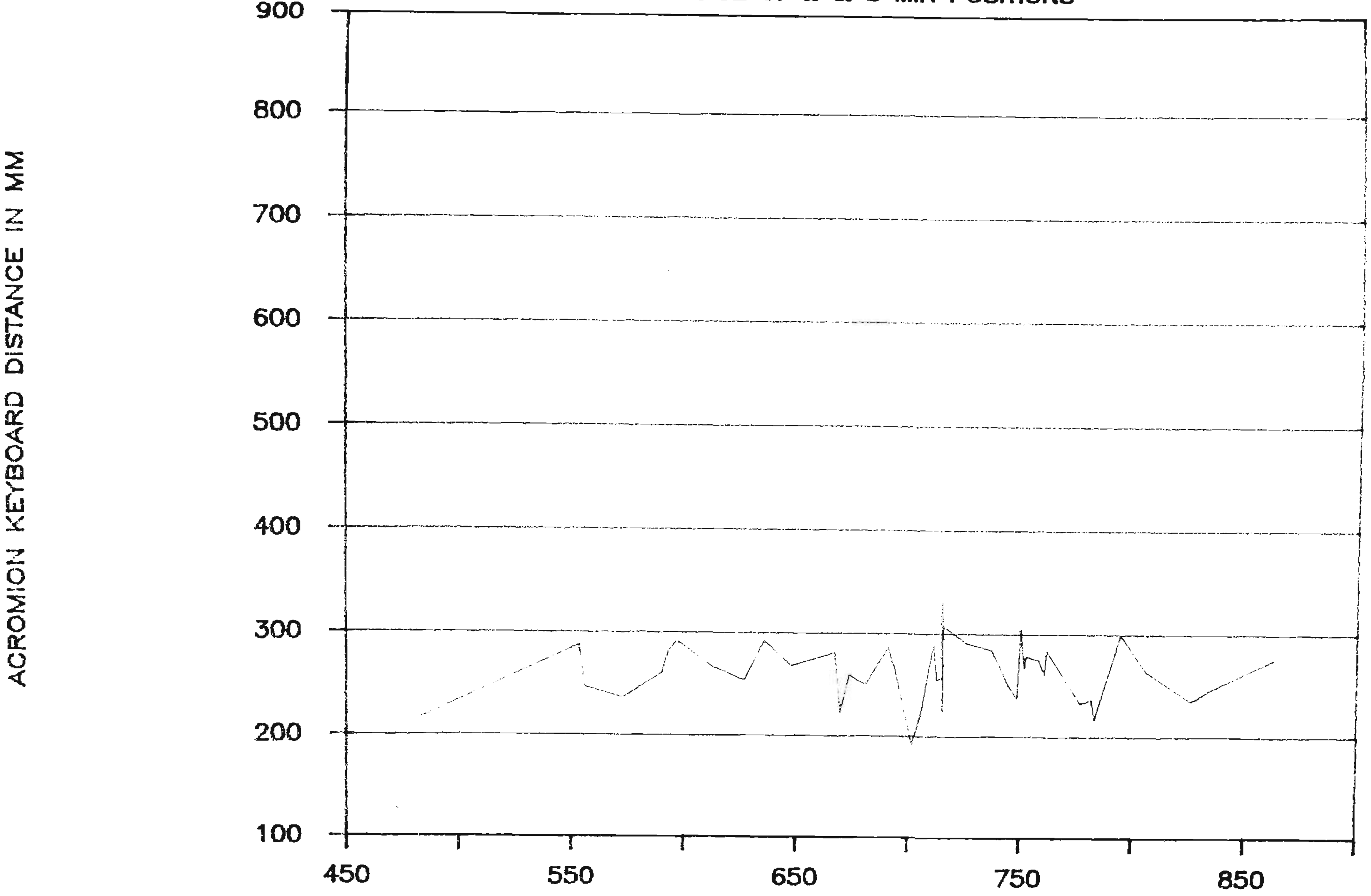
EYE COPY DIST v ACROM KBD DIST– GROUP B

AVG OF 2 & 8 MIN – LINE OF BEST FIT



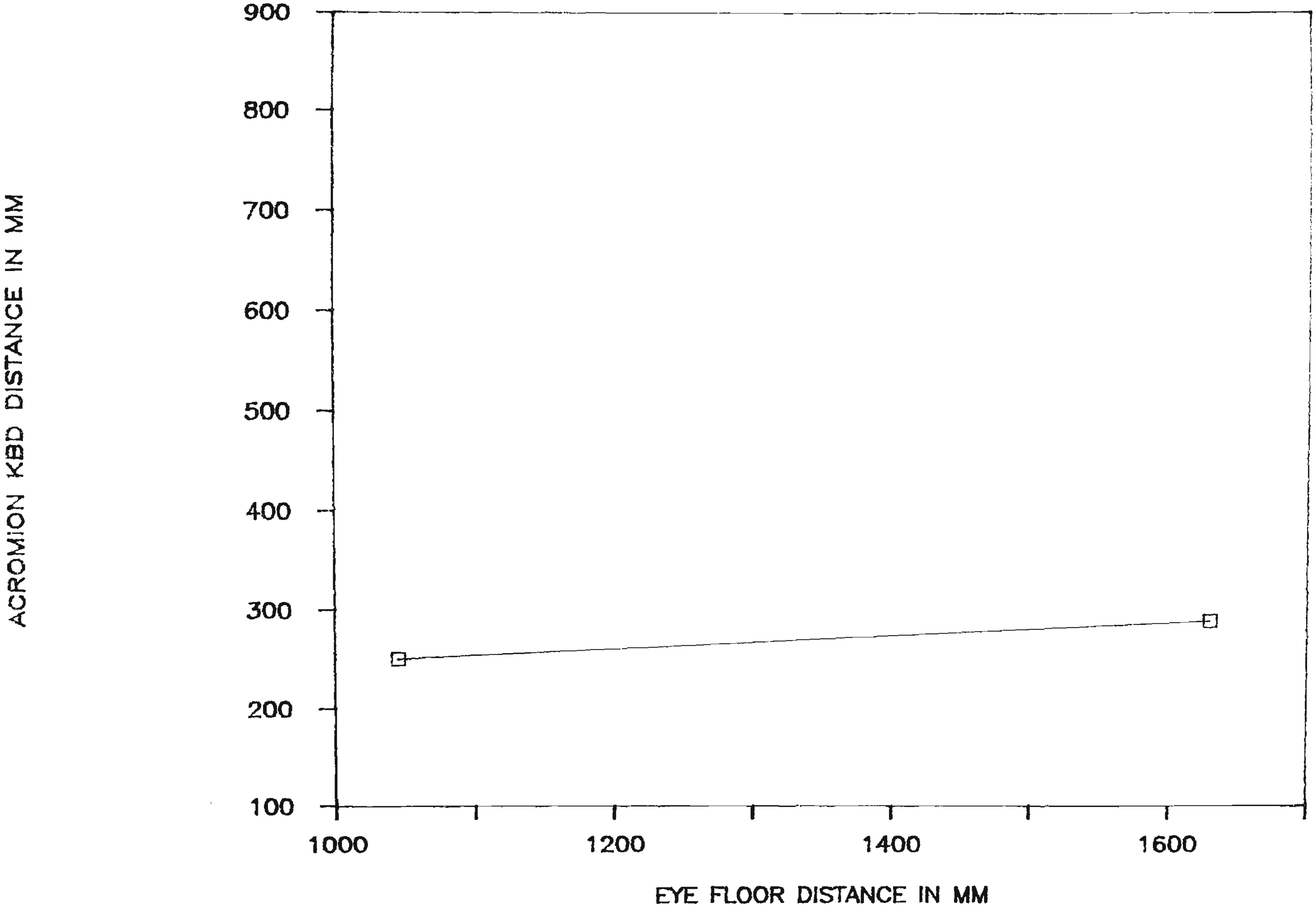
EYE COPY DIST v ACROM KBD DIST— GROUP B

AVERAGE OF 2 & 8 MIN POSITIONS



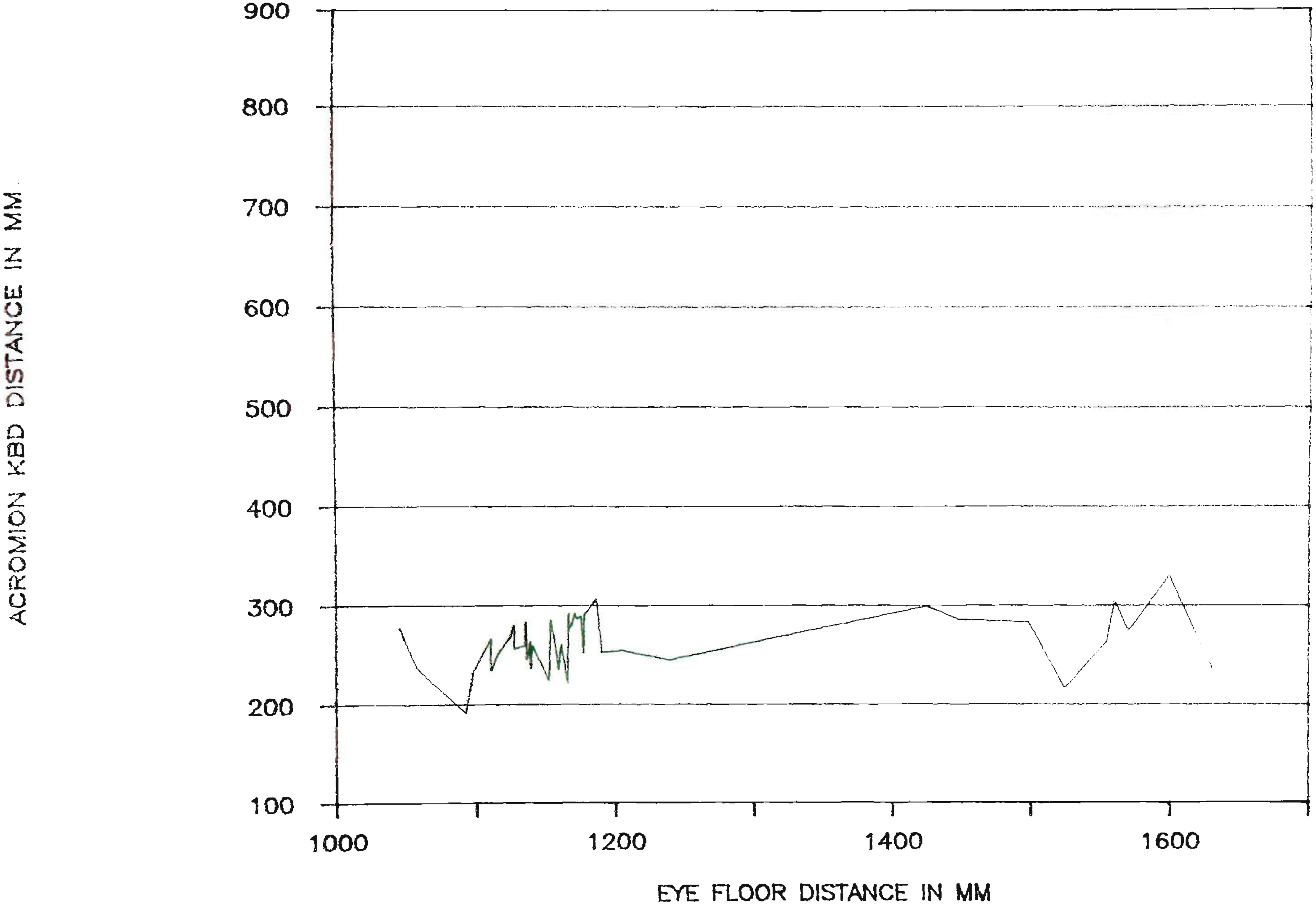
EYE FLOOR DIST v ACROM KBD DIST—GROUP B

AVG OF 2 & 8 MIN – LINE OF BEST FIT



EYE FLOOR DIST v ACROM KBD DIST—GROUP B

AVERAGE OF 2 & 8 MIN POSITIONS



APPENDICES

APPENDIX G - Statistical Summaries of t-Distribution Within and Between Groups, for the Nine Categories of Measurements.

The three Data Sets are:-

- comparison of the preferential seated working posture and that prescribed by the model after 2 and 8 minutes, respectively;

  Ho, u = model

  H1, u = model

- comparison of postural changes preferred by operators at the 2 and 8 minutes positions, compared against the seated working posture prescribed by the model;

  Ho, u at 2 minutes = u at 8 minutes

  H1, u at 2 minutes = u at 8 minutes

- test of significance between groups to establish whether or not experimental group A data is different to experimental group B data.

  Ho, u A = u B

  H1, u A = u B

CATEGORY:- EYE/FLOOR DISTANCE

STATISTIC :- t- DISTRIBUTION

POPULATION SAMPLE :- NORMAL

SYMMETRY :- SYMMETRICAL;

IT IS REASONABLE TO ASSUME THAT EYE FLOOR DISTANCES CORRESPOND TO THE STANDARD NORMAL DISTRIBUTION.

MEAN :- CORRESPONDS TO THE STANDARD NORMAL DISTRIBUTION.

WHERE :-

- NULL HYPOTHESIS (Ho) POPULATION EQUAL TO 1187mm (u)*
- OR POSITIVE HYPOTHESIS (H_1) POPULATION NOT EQUAL TO 1187mm (u)*
- SAMPLE SIZE (n) = 47
- AVERAGE = ($\bar{x}$)

  APPROXIMATELY NORMAL DUE TO LARGE SAMPLE SIZE.

- STANDARD DEVIATION = S

THEREFORE :-

$$Z = \frac{\bar{X} - u}{\frac{S}{\sqrt{n}}}$$

*"Average" data from "Humanscale" (1974) & not from I.O.S. (1978) - "The Model".

CATEGORY :- EYE/FLOOR DISTANCE

STATISTIC :- $\dfrac{\bar{X} - u}{\dfrac{S}{\sqrt{n}}}$

TEST ONE : -

H_0 u = 1187mm

H_1 u ≠ 1187mm

n = 47

GROUP A :-

AT 2 MINUTES

$$Z = \frac{1240 - 1187}{\dfrac{28.5}{\sqrt{47}}} = \frac{53}{4.157}$$

$$= 12.75$$

The result is statistically significant at the 1% confidence level of prediction. (<.01 **)

There is a significant difference between Humanscale "average" data and the experimental group; Experimental group A were definitely not sitting at eye/floor distance of 1187mm after after two minutes of work.

GROUP A : -

AT 8 MINUTES

$$Z = \frac{1241 - 1187}{\dfrac{22.8}{\sqrt{47}}} = \frac{54}{3.326}$$

$$= 16.236$$

The result is statistically significant at the 1% confidence level of prediction. (<.01 **)

There is a significant difference between Humanscale "average" data and the experimental group; Experimental group A were definitely not sitting at eye/floor distance of 1187mm after after eight minutes of work.

CATEGORY :- EYE/FLOOR DISTANCE

TEST ONE : -

$H_0 \quad u = 1187mm$

$H_1 \quad u \neq 1187mm$

$n = 47$

GROUP B :-

AT 2 MINUTES

$$Z = \frac{1213 - 1187}{\frac{159.5}{\sqrt{47}}} = \frac{26}{23.26}$$

$$= 1.12$$

The result is statistically significant at 10% confidence level of prediction. (<.10 *)

There is a significant difference between Humanscale "average" data and the experimental group. The minimum eye/floor distance recorded was 1005mm and the maximum 1680mm. The result indicates that experimental group B were not sitting at 1187mm eye/floor distance after two minutes of work.

GROUP B: -

AT 8 MINUTES

$$Z = \frac{1219 - 1187}{\frac{165.8}{\sqrt{47}}} = \frac{32}{24.18}$$

$$= 1.32$$

The result is statistically significant at 10% confidence level of prediction. (<.10 *)

There is a significant difference between Humanscale "average" data and the experimental group. The minimum eye/floor distance recorded was 1010mm and the maximum 1640mm. The result indicates that experimental group B were not sitting at 1187mm eye floor distance, after eight minutes of work.

CATEGORY : - EYE/FLOOR DISTANCE

TEST TWO : -

H_0, u at 2 minutes = u at 8 minutes

H_1, u at 2 minutes ≠ u at 8 minutes

$\overline{X}$ = the differences between the model* and the measurement of movement (average of 2 minute and 8 minute positions)

Degrees of freedom, N-1 for paired data.

*Humanscale (1974), "average" data used.

$$\overline{Z} = \frac{X - u}{\frac{S}{\sqrt{n}}}$$

GROUP A : -

AT 2 MINUTES AND 8 MINUTES (AVERAGES)

$$Z = \frac{10-0}{\frac{13.2}{\sqrt{47}}} = \frac{10}{1.925}$$

$$= 5.19$$

The result is statistically significant at the 1% confidence level of prediction. (<.01 **)

There is a significant difference between Humanscale "average" data and the experimental group. Group A were definitely moving over an eye/floor distance and not sitting statically at 1187mm eye height above the floor.

GROUP B : -

AT 2 MINUTES AND 8 MINUTES (AVERAGES)

$$Z = \frac{26 - 0}{\frac{27}{\sqrt{47}}} = \frac{26}{3.938}$$

$$= 6.6$$

The result is statistically significant at the 1% confidence level of prediction. (<.01 **)

There is a significant difference between Humanscale "average" data and the experimental group. Group B were definitely moving over an eye/floor distance and not sitting statically at 1187mm eye height above the floor.

CATEGORY : - EYE/FLOOR DISTANCE

TEST THREE :

TO TEST WHETHER OR NOT GROUP A DATA IS SIGNIFICANTLY DIFFERENT TO GROUP B DATA

S = STANDARD DEVIATION

H^{o}, $u_A = u_B$

H^{1}, $u_A \neq u_B$

THE TWO SAMPLES ARE STATISTICALLY LARGE NUMBERS

$$Z = \frac{\bar{X}_A - \bar{X}_B}{\sqrt{\frac{S^2_A}{n_a} + \frac{S^2_B}{n_b}}}$$

2 MINUTE POSITIONS :-

$$Z = \frac{1240 - 1213}{\sqrt{\frac{812.25}{47} + \frac{25440.25}{47}}} = \frac{27}{23.6}$$

$$= 1.14$$

The result is statistically significant at the 1% confidence level of prediction. (<.01 *)

There is no significant difference between Group A or Group B data at the two minutes sitting position.

8 MINUTES POSITIONS : -

$$Z = \frac{1241 - 1219}{\sqrt{\frac{519.84}{47} + \frac{27489}{47}}} = \frac{22}{24.41} = .9$$

The result is statistically significant at the 1% confidence level of prediction. (<.01 **)

There is no significant difference between Group A or Group B data at the eight minutes sitting position.

CATEGORY:- ACROMION/KEYBOARD DISTANCE

STATISTIC :- t- DISTRIBUTION

POPULATION SAMPLE :- NORMAL

SYMMETRY :- SYMMETRICAL;

IT IS REASONABLE TO ASSUME THAT ACROMION/KEYBOARD DISTANCES CORRESPOND TO THE STANDARD NORMAL DISTRIBUTION.

MEAN :- CORRESPONDS TO THE STANDARD NORMAL DISTRIBUTION.

WHERE :-

- NULL HYPOTHESIS (Ho) POPULATION EQUAL TO 274mm (u)*

- OR POSITIVE HYPOTHESIS (H_1) POPULATION NOT EQUAL TO 274mm (u)*

- SAMPLE SIZE (n) = 47

- AVERAGE = ($\bar{x}$)

  APPROXIMATELY NORMAL DUE TO LARGE SAMPLE SIZE.

- STANDARD DEVIATION = S

THEREFORE :-

$$Z = \frac{\bar{X} - u}{\frac{S}{\sqrt{n}}}$$

*Humanscale (1974) "average" Data used and not I.O.S (1978) data - "The Model"

CATEGORY :- ACROMION/KEYBOARD DISTANCE

STATISTIC : - $\dfrac{\bar{X} - u}{\dfrac{S}{\sqrt{n}}}$

TEST ONE : -

H_o u = 274mm*

H_1 u ≠ 274mm*

n = 47

*"Average" data from Humanscale (1974)

GROUP A :-

AT 2 MINUTES

$$Z = \frac{244 - 274}{\dfrac{34.7}{\sqrt{47}}} = \frac{30}{4.96}$$

$$= 6.05$$

The result is statistically significant at the 1% confidence level of prediction. (<.01 **)

There is a significant difference between the Humanscale (1974) "average" data and the experimental group. Group A were definitely not sitting with shoulder acromion 274mm above the home row of keys after eight minutes of work.

GROUP A : -

AT 8 MINUTES

$$Z = \frac{245 - 274}{\dfrac{32.3}{\sqrt{47}}} = \underline{29}$$

$$= 4.7$$

The result is statistically significant at the 1% confidence level of prediction. (<.01 **)

There is a significant difference between the Humanscale (1974) "average" data and the experimental group. Group A were definitely not sitting with shoulder acromion 274mm above the home row of keys after eight minutes of work.

CATEGORY :- ACROMION/KEYBOARD DISTANCE

TEST ONE : -

H_0 u = 274mm*

H_1 u ≠ 274mm*

n = 47

*"Average" data from Humanscale (1974)

GROUP B :-

AT 2 MINUTES

$$Z = \frac{262 - 274}{\frac{29.2}{\sqrt{47}}} = \frac{12}{4.26}$$

$$= 2.82$$

The result is statistically significant at the 1% confidence level of prediction. (<.01 **)

There is a significant difference between the Humanscale (1974) "average" data and the experimental group. Group B were definitely not sitting with shoulder acromion 274mm above the home row of keys after two minutes of work.

GROUP B : -

AT 8 MINUTES

$$Z = \frac{261 - 274}{\frac{28.8}{\sqrt{47}}} = \frac{13}{4.2}$$

$$= 3.09$$

The result is statistically significant at the 1% confidence level of prediction. (<.01 **)

There is a significant difference between the Humanscale (1974) "average" data and the experimental group. Group B were definitely not sitting with shoulder acromion 274mm above the home row of keys after eight minutes of work.

CATEGORY : - ACROMION/KEYBOARD DISTANCE

TEST TWO : -

H_0, u at 2 minutes = u at 8 minutes

H_1, u at 2 minutes ≠ u at 8 minutes

$\overline{X}$ = the differences between the model* and the measurement of movement (average of 2 minute and 8 minute positions)

Degrees of freedom, N-1 for paired data.

*"Average" data from humansacale (1974)

$$Z = \frac{\overline{X} - u}{\frac{S}{\sqrt{n}}}$$

GROUP A : -

AT 2 MINUTES AND 8 MINUTES (AVERAGES)

$$Z = \frac{11.0}{\frac{8.4}{\sqrt{47}}} = \frac{11}{1.23} = 8.9$$

The result is statistically significant at the 1% confidence level of prediction. (<.01 **)

There is a significant difference between the Humanscale (1974) "average" data and the experimental group. Group A were definitely not sitting with shoulder acromion 274mm above the home row of keys after two and eight minutes of work, respectively.

GROUP B : -

AT 2 MINUTES AND 8 MINUTES (AVERAGES)

$$Z = \frac{12.0}{\frac{9.9}{\sqrt{47}}} = \frac{12}{1.44} = 8.33$$

The result is statistically significant at the 1% confidence level of prediction. (<.01 **)

There is a significant difference between the Humanscale (1974) "average" data and the experimental group. Group B were definitely not sitting with shoulder acromion 274mm above the home row of keys after two and eight minutes of work, respectively.

CATEGORY : - ACROMION/KEYBOARD DISTANCE

TEST THREE :

TO TEST WHETHER OR NOT GROUP A DATA IS SIGNIFICANTLY DIFFERENT TO GROUP B DATA

S = STANDARD DEVIATION

H^{O}, $u_A = u_B$

H^{1}, $u_A \neq u_B$

THE TWO SAMPLES ARE STATISTICALLY LARGE NUMBERS

$$. \quad Z = \frac{\bar{X}A - \bar{X}B}{\sqrt{\frac{S^2 A}{n\,a} + \frac{S^2 B}{n\,b}}}$$

2 MINUTE POSITIONS :-

$$Z = \frac{2.44 - 262}{\sqrt{\frac{1204.09}{47} + \frac{852.64}{47}}} = \frac{18}{6.6}$$

$$= 2.73$$

The result is statistically significant at the 1% confidence level of prediction. (<.01 **)

There is a significant difference between Group A and Group B at the two minutes sitting position.

8 MINUTES POSITIONS : -

$$Z = \frac{2435 - 261}{\sqrt{\frac{1043.29}{47} + \frac{829.44}{47}}} = \frac{16}{6.3}$$

$$= 2.54$$

The result is statistically significant at the 1% confidence level of prediction. (<.01 **)

There is a significant difference between Group A and Group B at the eight minutes sitting position.

CATEGORY:- EYE/COPY DISTANCE

STATISTIC :- t- DISTRIBUTION

POPULATION SAMPLE :- NORMAL

SYMMETRY :- SYMMETRICAL;

IT IS REASONABLE TO ASSUME THAT EYE/COPY DISTANCES CORRESPOND TO THE STANDARD NORMAL DISTRIBUTION.

MEAN :- CORRESPONDS TO THE STANDARD NORMAL DISTRIBUTION.

DEGREES OF FREEDOM :- N - 1 FOR PAIRED DATA

WHERE :-

- NULL HYPOTHESIS (Ho) POPULATION EQUAL TO 460mm (u)*
- OR POSITIVE HYPOTHESIS (H_1) POPULATION NOT EQUAL TO 460mm (u)*
- SAMPLE SIZE (n) = 47
- AVERAGE = ($\bar{x}$)

  APPROXIMATELY NORMAL DUE TO LARGE SAMPLE SIZE.
- STANDARD DEVIATION = S

THEREFORE :-

$$Z = \frac{\bar{X} - u}{\frac{S}{\sqrt{n}}}$$

*Humanscale (1974) "average" data and not from I.O.S. (1978) - "The Model"

CATEGORY :- EYE/COPY DISTANCE

STATISTIC : - $\dfrac{\bar{X} - u}{S / \sqrt{n}}$

TEST ONE : -

$H_0 \quad u = 460mm$

$H_1 \quad u \neq 460mm$

$n = 47$

GROUP A :-

AT 2 MINUTES

$$Z = \frac{670 - 460}{50.6 / \sqrt{47}} = \frac{210}{7.38}$$

$$= 28.45$$

The result is statistically significant at the 1% confidence level of prediction. (<.01 **)

There is a significant difference between the Humanscale (1974) "average" data and the experimental group. Group A were definitely not sitting at viewing distance to copy/screen of 460mm after two minutes of work.

GROUP A : -

AT 8 MINUTES

$$Z = \frac{671 - 460}{52.2 / \sqrt{47}} = \frac{211}{7.61}$$

$$= 27.73$$

The result is statistically significant at the 1% confidence level of prediction. (<.01 **)

There is a significant difference between the Humanscale (1974) "average" data and the experimental group. Group A were definitely not sitting at viewing distance to copy/screen of 460mm after eight minutes of work.

CATEGORY :- EYE/COPY DISTANCE

TEST ONE : -

H_o u = 460mm

H_1 u ≠ 460mm

n = 47

GROUP B :-

AT 2 MINUTES

$$Z = \frac{700 - 460}{\sqrt{\frac{77.4}{47}}} = \frac{240}{11.29}$$

$= 21.26$

The result is statistically significant at the 1% confidence level of prediction. (<.01 **)

There is a significant difference between the Humanscale (1974) "average" data and the experimental group. Group B were definitely not sitting at viewing distance to copy/screen of 460mm after two minutes of work.

GROUP B : -

AT 8 MINUTES

$$Z = \frac{707 - 469}{\sqrt{\frac{87.0}{47}}} = \frac{247}{12.69}$$

$= 19.46$

The result is statistically significant at the 1% confidence level of prediction. (<.01 **)

There is a significant difference between the Humanscale (1974) "average" data and the experimental group. Group B were definitely not sitting at viewing distance to copy/screen of 460mm after eight minutes of work.

CATEGORY : - EYE/COPY DISTANCE

TEST TWO : -

H_0, u at 2 minutes = u at 8 minutes

H_1, u at 2 minutes ≠ u at 8 minutes

$\overline{X}$ = the differences between the model and the measurement of movement (average of 2 minute and 8 minute positions)

Degrees of freedom, H-1 for paired data.

$$Z = \frac{\overline{X} - u}{\sqrt{\frac{S}{n}}}$$

GROUP A : -

AT 2 MINUTES AND 8 MINUTES (AVERAGES)

$$Z = \frac{17 - 0}{\sqrt{\frac{18.3}{47}}} = \frac{17}{2.67}$$

$$= 6.36$$

The result is statistically significant at the 1% confidence level of prediction. (<.01 **)

There is a significant difference between the Humanscale (1974) "average" data and the experimental group. Group A were definitely moving and not sitting at eye distance to copy/screen of 460mm after two and eight minutes of work, respectively.

GROUP B : -

AT 2 MINUTES AND 8 MINUTES (AVERAGES)

$$Z = \frac{26.0}{\sqrt{\frac{21.3}{47}}} = \frac{26}{3.11}$$

$$= 8.36$$

The result is statistically significant at the 1% confidence level of prediction. (<.01 **)

There is a significant difference between the Humanscale (1974) "average" data and the experimental group. Group B were definitely moving and not sitting at eye distance to copy/screen of 460mm after two and eight minutes of work, respectively.

CATEGORY : - EYE/COPY DISTANCE

TEST THREE :

TO TEST WHETHER OR NOT GROUP A DATA IS SIGNIFICANTLY DIFFERENT TO GROUP B DATA

S = STANDARD DEVIATION

H^o, $u A = u B$

H^1, $u A \neq u B$

THE TWO SAMPLES ARE STATISTICALLY LARGE NUMBERS

$$. \quad Z = \frac{\bar{X} A - \bar{X} B}{\sqrt{\frac{S^2 A}{n a} + \frac{S^2 B}{n b}}}$$

2 MINUTE POSITIONS :-

$$Z = \frac{670 - 700}{\sqrt{\frac{2560.36}{47} + \frac{599.1}{47}}} = \frac{30}{8.2}$$

$= 3.7$

The result is statistically significant at the confidence level of prediction. (<.01 **)

Group A data is significantly different to Group B data.

8 MINUTES POSITIONS : -

$$Z = \frac{671 - 707}{\sqrt{\frac{2560.36}{47} + \frac{5990.76}{47}}} = \frac{36}{14.8}$$

$= 2.4$

The result is statistically significant at the 1% confidence level of prediction. (<.01 **)

Group A data is significantly different to Group B data.

CATEGORY:- TRUNK INCLINATION

STATISTIC :- t- DISTRIBUTION

POPULATION SAMPLE :- NORMAL

SYMMETRY :- SYMMETRICAL;

IT IS REASONABLE TO ASSUME THAT TRUNK INCLINATIONS CORRESPOND TO THE STANDARD NORMAL DISTRIBUTION

MEAN :- CORRESPONDS TO THE STANDARD NORMAL DISTRIBUTION

WHERE :-

- NULL HYPOTHESIS (Ho) POPULATION EQUAL TO 90^o (u)
- OR POSITIVE HYPOTHESIS (H_1) POPULATION NOT EQUAL TO 90^o (u)
- SAMPLE SIZE (n) = 47
- AVERAGE = ($\bar{x}$)

  APPROXIMATELY NORMAL DUE TO LARGE SAMPLE SIZE.
- STANDARD DEVIATION = S

THERETFORE :-

$$Z = \frac{\bar{X} - u}{\frac{S}{\sqrt{n}}}$$

CATEGORY :- TRUNK INCLINATION

STATISTIC : - $\dfrac{\bar{X} - u}{\dfrac{S}{\sqrt{n}}}$

TEST ONE : -

H_0 $u = 90^\circ$

H_1 $u \neq 90^\circ$

$n = 47$

GROUP A :-

AT 2 MINUTES

$$Z = \frac{108.9 - 90}{\frac{10.1}{\sqrt{47}}} = \frac{18.9}{1.473}$$

$$= 12.8$$

The result is statistically significant at the 1% confidence level of prediction. (<.01 **)

There is a significant difference between the model and the experimental group; experimental group A were definitely not sitting at 90° trunk inclination after two minutes of work.

GROUP A : -

AT 8 MINUTES

$$Z = \frac{110.1 - 90}{\frac{10.3}{\sqrt{47}}} = \frac{20.1}{1.502}$$

$$= 13.38$$

The result is statistically significant at the 1% confidence level of prediction. (<.01 **)

There is a significant difference between the model and the experimental group; experimental group A were definitely not sitting at 90° trunk inclination after eight minutes of work.

CATEGORY :- TRUNK INCLINATION

TEST ONE : -

H_o u = 90^o

H_1 u $\neq$ 90^o

n = 47

GROUP B :-

AT 2 MINUTES

$$Z = \frac{107 - 90}{\frac{10.7}{\sqrt{47}}} = \frac{17}{1.561}$$

$$= 10.89$$

The result is statistically significant at the 1% confidence level of prediction. (<.01 **)

There is a significant difference between the model and the experimental group; experimental group B were definitely not sitting at 90^o trunk inclination after two minutes of work.

GROUP B : -

AT 8 MINUTES

$$Z = \frac{107.6 - 90}{\frac{11.0}{\sqrt{47}}} = \frac{17.6}{1.605}$$

$$= 10.96$$

The result is statistically significant at the 1% confidence level of prediction. (<.01 **)

There is a significant difference between the model and the experimental group; experimental group B were definitely not sitting at 90^o trunk inclination after eight minutes of work.

CATEGORY : - TRUNK INCLINATION

TEST TWO : -

H_0, u at 2 minutes = u at 8 minutes

H_1, u at 2 minutes ≠ u at 8 minutes

$\overline{X}$ = the differences between the model and the measurement of movement (average of 2 minute and 8 minute positions)

Degrees of freedom, N-1 for paired data

$$Z = \frac{\overline{X} - u}{\frac{S}{\sqrt{n}}}$$

GROUP A : -

AT 2 MINUTES AND 8 MINUTES (AVERAGES)

$$Z = \frac{5.5 - 0}{\frac{5.5}{\sqrt{47}}} = \frac{5.5}{0.802}$$

$$= 6.8$$

The result is statistically significant at the 1% confidence level of prediction. (<.01 **)

There is a significant difference between the model and the experimental group; experimental group A were definitely moving and not sitting at 90^{o} trunk inclination after two minutes and eight minutes of work, respectively.

GROUP B : -

AT 2 MINUTES AND 8 MINUTES (AVERAGES)

$$Z = \frac{6.9 - 0}{\frac{5.4}{\sqrt{47}}} = \frac{6.9}{0.788}$$

$$= 8.756$$

The result is statistically significant at the 1% confidence level of prediction. (<.01 **)

There is a significant difference between the model and the experimental group; experimental group B were definitely moving and not sitting at 90^{o} trunk inclination after two minutes and eight minutes of work respectively.

CATEGORY : - TRUNK INCLINATION

TEST THREE :

TO TEST WHETHER OR NOT GROUP A DATA IS SIGNIFICANTLY DIFFERENT TO GROUP B DATA

S = STANDARD DEVIATION

H_0, $u\ A = u\ B$

H_1, $u\ A \neq u\ B$

THE TWO SAMPLES ARE STATISTICALLY LARGE NUMBERS

$$. \quad Z = \frac{\bar{X}A - \bar{X}B}{\sqrt{\frac{S^2 A}{n\ a} + \frac{S^2 B}{n\ b}}}$$

2 MINUTE POSITIONS :-

$$Z = \frac{108.9 - 107}{\sqrt{\frac{102}{47} + \frac{114}{47}}} = \frac{1.9}{2.143}$$

$$= .89$$

The result is close to the mean expectancy of a normally distributed population.

There is no significant difference between Group A or Group B data at the two minutes sitting position.

8 MINUTES POSITIONS : -

$$Z = \frac{110.1 - 107.6}{\sqrt{\frac{106.09}{47} + \frac{122}{47}}} = \frac{2.5}{4.853}$$

$$= .52$$

The result is close to the mean expectancy of a normally distributed population.

There is no significant difference between Group A or Group B data at the eight minutes sitting positions.

CATEGORY:- HEAD INCLINATION

STATISTIC :- t- DISTRIBUTION

POPULATION SAMPLE :- NORMAL

SYMMETRY :- SYMMETRICAL;

IT IS REASONABLE TO ASSUME THAT HEAD INCLINATIONS CORRESPOND TO THE STANDARD NORMAL DISTRIBUTION

MEAN :- CORRESPONDS TO THE STANDARD NORMAL DISTRIBUTION

WHERE :-

- NULL HYPOTHESIS (Ho) POPULATION EQUAL TO 0^o (u)
- OR POSITIVE HYPOTHESIS (H_1) POPULATION NOT EQUAL TO 0^o (u)
- SAMPLE SIZE (n) = 47
- AVERAGE = ($\bar{x}$)

  APPROXIMATELY NORMAL DUE TO LARGE SAMPLE SIZE.
- STANDARD DEVIATION = S

THEREFORE :-

$$Z = \frac{\bar{X} - u}{\frac{S}{\sqrt{n}}}$$

CATEGORY :- HEAD INCLINATION

STATISTIC : - $\dfrac{\bar{X} - u}{\dfrac{S}{\sqrt{n}}}$

TEST ONE : -

H_o u = 0°
H_1 u = 0°
n = 47

GROUP A :-

AT 2 MINUTES

$$Z = \frac{43. - 0}{\frac{9.1}{\sqrt{47}}} = \frac{43}{1.33}$$

$$= 32.33$$

The result is statistically significant at the 1% confidence level of prediction. (<.01 **)

There is a significant difference between the model and the experimental group; experimental group A were definitely not sitting with no head inclination after two minutes of work.

GROUP A : -

AT 8 MINUTES

$$Z = \frac{43.6 - 0}{\frac{9.4}{\sqrt{47}}} = \frac{43.6}{1.37}$$

$$= 31.82$$

The result is statistically significant at the 1% confidence level of prediction. (<.01 **)

There is a significant difference between the model and the experimental group; group A were definitely not sitting with no head inclination after eight minutes of work.

CATEGORY :- HEAD INCLINATION

TEST ONE : -

H_o u = 0^o
H_1 u = 0^o
n = 47

GROUP B :-

AT 2 MINUTES

$$Z = \frac{32.2 - 0}{\frac{6.2}{\sqrt{47}}} = \frac{32.2}{4.66}$$

$$= 6.91$$

The result is statistically significant at the 1% confidence level of prediction. (<.01 **)

There is a significant difference between the model and the experimental group; experimental group B were definitely not sitting with no head inclination after two minutes of work.

GROUP B : -

AT 8 MINUTES

$$Z = \frac{30.3 - 0}{\frac{9.4}{\sqrt{47}}} = \frac{30.3}{1.38}$$

$$= 21.96$$

The result is statistically significant at the 1% confidence level of prediction. (<.01 **)

There is a significant difference between the model and the experimental group; experimental group B were definitely not sitting with no head inclination after eight minutes of work.

CATEGORY : - HEAD INCLINATION

TEST TWO : -

H_0, u at 2 minutes = u at 8 minutes

H_1, u at 2 minutes ≠ u at 8 minutes

$\bar{X}$ = the differences between the model and the measurement of movement (average of 2 minute and 8 minute positions)

Degrees of freedom, N-1 for paired data

$$Z = \frac{\bar{X} - u}{\frac{S}{\sqrt{n}}}$$

GROUP A : -

AT 2 MINUTES AND 8 MINUTES (AVERAGES)

$$Z = \frac{6.4 - 0}{\frac{4.9}{\sqrt{47}}} = \frac{6.4}{0.714}$$

$$= 8.96$$

The result is statistically significant at the 1% confidence level of prediction. (<.01 **)

There is a significant difference between the model and the experimental group; experimental group A were definitely moving and not sitting with zero head inclination after two minutes and eight minutes of work, respectively.

GROUP B : -

AT 2 MINUTES AND 8 MINUTES (AVERAGES)

$$Z = \frac{6.2 - 0}{\frac{5.1}{\sqrt{47}}} = \frac{6.2}{0.743}$$

$$= 8.34$$

The result is statistically significant at the 1% confidence level of prediction. (<.01 **)

There is a significant difference between the model and the experimental group; experimental group B were definitely moving and not siting with zero head inclination after two minutes and eight minutes of work respectively.

CATEGORY : - HEAD INCLINATION

TEST THREE :

TO TEST WHETHER OR NOT GROUP A DATA IS SIGNIFICANTLY DIFFERENT TO GROUP B DATA

S = STANDARD DEVIATION

H_0, u A = u B

H_1, u A ≠ u B

THE TWO SAMPLES ARE STATISTICALLY LARGE NUMBERS

$$Z = \frac{\bar{X}A - \bar{X}B}{\sqrt{\frac{S^2 A}{n a} + \frac{S^2 B}{n b}}}$$

2 MINUTE POSITIONS :-

$$Z = \frac{43. - 32.3}{\sqrt{\frac{82.81}{47} + \frac{38.44}{47}}} = \frac{10.7}{1.135}$$

$$= 9.427$$

The result is statistically significant at the 1% confidence level of prediction (<.01**)

There is a significant difference between Group A and Group B head inclinations after 2 minutes of work.

8 MINUTES POSITIONS : -

$$Z = \frac{43.6 - 30.3}{\sqrt{\frac{88.36}{47} + \frac{88.36}{47}}} = \frac{13.3}{1.88}$$

$$= 7.07$$

The result is statistically significant at the 1% confidence level of prediction (<.01**)

There is a significant difference between Group A and Group B head inclinations after 8 minutes of work.

CATEGORY:- ARM FLEXION

STATISTIC :- t- DISTRIBUTION

POPULATION SAMPLE :- NORMAL

SYMMETRY :- SYMMETRICAL;

IT IS REASONABLE TO ASSUME THAT ARM FLEXIONS CORRESPOND TO THE STANDARD NORMAL DISTRIBUTION.

MEAN :- CORRESPONDS TO THE STANDARD NORMAL DISTRIBUTION.

WHERE :-

- NULL HYPOTHESIS (Ho) POPULATION EQUAL TO 90° (u)

- OR POSITIVE HYPOTHESIS (H_1) POPULATION NOT EQUAL TO 90° (u)

- SAMPLE SIZE (n) = 47

- AVERAGE = ($\bar{x}$)

  APPROXIMATELY NORMAL DUE TO LARGE SAMPLE SIZE.

- STANDARD DEVIATION = S

THEREFORE :-

$$Z = \frac{\bar{X} - u}{\frac{S}{\sqrt{n}}}$$

CATEGORY :- ARM FLEXION

STATISTIC : - $\frac{X - u}{S / \sqrt{n}}$

TEST ONE : -

H_o u = 90^o

H_1 u ≠ 90^o

n = 47

GROUP A :-

AT 2 MINUTES

$$Z = \frac{105.3 - 90}{7.8 / \sqrt{47}} = \frac{15.3}{1.378}$$

$= 11.1$

The result is statistically significant at the 1% confidence level of prediction. (<.01 **)

There is a significant difference between the model and the experimental group; experimental group A were definitely not sitting with the arms flexed at 90^o after two minutes of work.

GROUP A : -

AT 8 MINUTES

$$Z = \frac{106.6 - 90}{8.3 / \sqrt{47}} = \frac{16.6}{1.211}$$

$= 13.71$

The result is statistically significant at the 1% confidence level of prediction. (<.01 **)

There is a significant difference between the model and the experimental group; experimental group A were definitely not sitting with the arms flexed at 90^o after eight minutes of work.

CATEGORY :- ARM FLEXION

TEST ONE : -

$H_0 \quad u = 90^\circ$

$H_1 \quad u \neq 90^\circ$

$n = 47$

GROUP B :-

AT 2 MINUTES

$$Z = \frac{103.4 - 90}{\frac{7.8}{\sqrt{47}}} = \frac{13.4}{1.1377}$$

$$= 11.778$$

The result is statistically significant at the 1% confidence level of prediction. (<.01 **)

There is a significant difference between the model and the experimental group; experimental group B were definitely not sitting with the arms flexed at 90° after two minutes of work.

GROUP B : -

AT 8 MINUTES

$$Z = \frac{103.8 - 90}{\frac{7.4}{\sqrt{47}}} = \frac{13.8}{1.0794}$$

$$= 12.784$$

The result is statistically significant at the 1% confidence level of prediction. (<.01 **)

There is a significant difference between the model and the experimental group; experimental group B were definitely not sitting with the arms flexed at 90° after eight minutes of work.

CATEGORY : - ARM FLEXION

TEST TWO : -

H_0, u at 2 minutes = u at 8 minutes

H_1, u at 2 minutes ≠ u at 8 minutes

$\bar{X}$ = the differences between the model and the measurement of movement (average of 2 minute and 8 minute positions).

Degrees of freedom, N-1 for paired data.

$$Z = \frac{\bar{X} - u}{\frac{S}{\sqrt{n}}}$$

GROUP A : -

AT 2 MINUTES AND 8 MINUTES (AVERAGES)

$$Z = \frac{4.8 - 0}{\frac{4.1}{\sqrt{47}}} = \frac{4.8}{0.598}$$

$$= 8.023$$

The result is statistically significant at the 1% confidence level of prediction. (<.01 **)

There is a significant difference between the model and the experimental group; experimental group A were definitely moving and not sitting with the arms flexed at 90° after two minutes and eight minutes of work, respectively.

GROUP B : -

AT 2 MINUTES AND 8 MINUTES (AVERAGES)

$$Z = \frac{4.4 - 0}{\frac{5.1}{\sqrt{47}}} = \frac{4.4}{0.7439}$$

$$= 5.9$$

The result is statistically significant at the 1% confidence level of prediction. (<.01 **)

There is a significant difference between the model and the experimental group; experimental group B were definitely moving and not sitting with the arms flexed at 90° after two minutes and eight minutes of work respectively.

CATETORY : - ARM FLEXION

TEST THREE :

TO TEST WHETHER OR NOT GROUP A DATA IS SIGNIFICANTLY DIFFERENT TO GROUP B DATA

S = STANDARD DEVIATION

H^o, $u_A = u_B$

H^1, $u_A \neq u_B$

THE TWO SAMPLES ARE STATISTICALLY LARGE NUMBERS

$$Z = \frac{\bar{X}_A - \bar{X}_B}{\sqrt{\frac{S^2_A}{n_a} + \frac{S^2_B}{n_b}}}$$

2 MINUTE POSITIONS :-

$$Z = \frac{105.3 - 103.4}{\sqrt{\frac{60.84}{47} + \frac{60.84}{47}}} = \frac{1.9}{1.609}$$

$$= 1.18$$

There is no significant difference between Group A or Group B data at the two minute sitting positions. (<.10 *)

8 MINUTES POSITIONS : -

$$Z = \frac{106.6 - 103.8}{\sqrt{\frac{68.89}{47} + \frac{54.76}{47}}} = \frac{2.8}{1.622}$$

$$= 1.73$$

There is no significant difference between Group A or Group B data at the eight minute sitting positions. (<.10 *)

CATEGORY :- ARM ABDUCTION

STATISTIC :- t- DISTRIBUTION

POPULATION SAMPLE :- NORMAL

SYMMETRY :- SYMMETRICAL;

IT IS REASONABLE TO ASSUME THAT ARM ABDUCTIONS CORRESPOND TO THE STANDARD NORMAL DISTRIBUTION.

MEAN :- CORRESPONDS TO THE STANDARD NORMAL DISTRIBUTION.

WHERE :-

- NULL HYPOTHESIS (Ho) POPULATION EQUAL TO 0^{o} (u)

- OR POSITIVE HYPOTHESIS (H_1) POPULATION NOT EQUAL TO 0^{o} (u)

- SAMPLE SIZE (n) = 47

- AVERAGE = ($\bar{x}$)

  APPROXIMATELY NORMAL DUE TO LARGE SAMPLE SIZE.

- STANDARD DEVIATION = S

THEREFORE :-

$$Z = \frac{\bar{X} - u}{\frac{S}{\sqrt{n}}}$$

CATEGORY :- ARM ABDUCTION

STATISTIC : - $$\frac{\bar{X} - u}{\frac{S}{\sqrt{n}}}$$

TEST ONE : -

H_o u = 90^o

H_1 u ≠ 90^o

n = 47

GROUP A :-

AT 2 MINUTES

$$Z = \frac{23.6 - 0}{\frac{6.8}{\sqrt{47}}} = \frac{23.6}{0.992}$$

$$= 23.79$$

The result is statistically significant at the 1% confidence level of prediction. (<.01 **)

There is a significant difference between the model and the experimental group; experimental group A were definitely not sitting with upper arms parallel to the bodies sides after two minutes of work.

GROUP A : -

AT 8 MINUTES

$$Z = \frac{24. - 0}{\frac{6.2}{\sqrt{47}}} = \frac{24}{.904}$$

$$= 26.55$$

The result is statistically significant at the 1% confidence level of prediction. (<.01 **)

There is a significant difference between the model and the experimental group; experimental group A were definitely not sitting with upper arms parallel to the bodies sides after eight minutes of work.

CATEGORY :- ARM ABDUCTION

STATISTIC : - $\frac{\bar{X} - u}{S / \sqrt{n}}$

TEST ONE : -

H_o u = 90^o

H_1 u $\neq$ 90^o

n = 47

GROUP B :-

AT 2 MINUTES

$$Z = \frac{24.9 - 0}{5.8 / \sqrt{47}} = \frac{24.9}{.846}$$

$$= 29.43$$

The result is statistically significant at the 1% confidence level of prediction. (<.01 **)

There is a significant difference between the model and the experimental group; experimental group B were definitely not sitting with upper arms parallel to the bodies sides after two minutes of work.

GROUP B : -

AT 8 MINUTES

$$Z = \frac{25.0}{6.1 / \sqrt{47}} = \frac{25}{0.889}$$

$$= 28.12$$

The result is statistically significant at the 1% confidence level of prediction. (<.01 **)

There is a significant difference between the model and the experimental group; experimental group B were definitely not sitting with upper arms parallel to the bodies sides after eight minutes of work.

CATEGORY :- ARM ABDUCTION

STATISTIC : - $\dfrac{\bar{X} - u}{\dfrac{S}{\sqrt{n}}}$

TEST ONE : -

$H_o \quad u = 90^o$

$H_1 \quad u \neq 90^o$

$n = 47$

GROUP B :-

AT 2 MINUTES

$$Z = \frac{23.6 - 0}{\frac{6.8}{\sqrt{47}}} = \frac{23.6}{0.992}$$

$$= 23.79$$

There is a significant difference between the model and the experimental group; experimental group A were definitely not sitting with upper arms parallel to the bodies sides after two minutes of work.

The result is statistically significant at greater than the .01 (1%) confidence level of prediction for t - distribution at 2.576 (total area in both tails - normal distribution).

GROUP A : -

AT 8 MINUTES

$$Z = \frac{24.0}{\frac{6.2}{\sqrt{47}}} = \frac{24}{.904}$$

$$= 26.55$$

There is a significant difference between the model and the experimental group; experimental group A were definitely not sitting with upper arms parallel to the bodies sides after eight minutes of work.

The result is statistically significant at greater than the .01 (1%) confidence level of prediction for t - distribution at 2.576 (total area in both tails - normal distribution).

CATEGORY : - ARM ABDUCTION

TEST TWO : -

H_0, u at 2 minutes = u at 8 minutes

H_1, u at 2 minutes ≠ u at 8 minutes

$\bar{X}$ = the differences between the model and the measurement of movement (average of 2 minute and 8 minute positions)

Degrees of freedom, N-1 for paired data.

$$Z = \frac{\bar{X} - u}{\frac{S}{\sqrt{n}}}$$

GROUP A : -

AT 2 MINUTES AND 8 MINUTES (AVERAGES)

$$Z = \frac{2.9 - 0}{\frac{2.9}{\sqrt{47}}} = \frac{2.9}{0.432}$$

$$= 6.713$$

GROUP B : -

AT 2 MINUTES AND 8 MINUTES (AVERAGES)

$$Z = \frac{41. - 0}{\frac{2.9}{\sqrt{47}}} = \frac{4.1}{0.432}$$

$$= 9.49$$

The result is statistically significant at the 1% confidence level of prediction. (<.01 **)

There is a significant difference between the model and the experimental groups; experimental groups A & B were definitely not sitting with upper arms parallel to the bodies sides after two and eight minutes of work, respectively.

CATEGORY : - ARM ABDUCTION

TEST THREE :

TO TEST WHETHER OR NOT GROUP A DATA IS SIGNIFICANTLY DIFFERENT TO GROUP B DATA

S = STANDARD DEVIATION

H^o, $u A = u B$

H^1, $u A \neq u B$

THE TWO SAMPLES ARE STATISTICALLY LARGE NUMBERS

$$. \quad Z = \frac{\bar{X} A - \bar{X} B}{\sqrt{\frac{S^2 A}{n a} + \frac{S^2 B}{n b}}}$$

2 MINUTE POSITIONS :-

$$Z = \frac{23.6 - 24.9}{\sqrt{\frac{46.24}{47} + \frac{33.64}{47}}} = \frac{-1.3}{1.303}$$

$$= .997$$

The result is close to the mean expectancy of a normally distributed population.

There is no significant difference between Group A or Group B data at the two minutes sitting position.

8 MINUTES POSITIONS : -

$$Z = \frac{24. - 25.}{\sqrt{\frac{38.44}{47} + \frac{37.21}{47}}} \quad \frac{-1.}{1.267}$$

$$= .788$$

The result is close to the mean expectancy of a normally distributed population.

There is no significant difference between Group A or Group B data at the two minutes sitting position.

CATEGORY:- ELBOW ANGLE

STATISTIC :- t- DISTRIBUTION

POPULATION SAMPLE :- NORMAL

SYMMETRY :- SYMMETRICAL;

IT IS REASONABLE TO ASSUME THAT ELBOW ANGLES CORRESPOND TO THE STANDARD NORMAL DISTRIBUTION.

MEAN :- CORRESPONDS TO THE STANDARD NORMAL DISTRIBUTION.

WHERE :-

- NULL HYPOTHESIS (Ho) POPULATION EQUAL TO 90^{o} (u)

- OR POSITIVE HYPOTHESIS (H_1) POPULATION NOT EQUAL TO 90^{o} (u)

- SAMPLE SIZE (n) = 47

- AVERAGE = ($\bar{x}$)

  APPROXIMATELY NORMAL DUE TO LARGE SAMPLE SIZE.

- STANDARD DEVIATION = S

THEREFORE :-

$$Z = \frac{\bar{X} - u}{\frac{S}{\sqrt{n}}}$$

CATEGORY :- ELBOW ANGLE

STATISTIC : - $\dfrac{\bar{X} - u}{\dfrac{S}{\sqrt{n}}}$

TEST ONE : -

$H_0 \quad u = 90^{o}$

$H_1 \quad u \neq 90^{o}$

$n = 47$

GROUP A :-

AT 2 MINUTES

$$Z = \frac{90 - 90}{\frac{9.1}{\sqrt{47}}} = \frac{0}{1.327}$$

$$= 0$$

There is no significant, measurable difference between the model and experimental group A after two minutes of work.

GROUP A : -

AT 8 MINUTES

$$Z = \frac{90.6 - 90.0}{\frac{8.6}{\sqrt{47}}} = \frac{.6}{1.254}$$

$$= .478$$

There is no significant, measurable difference between the model and experimental group A after eight minutes of work.

CATEGORY :- ELBOW ANGLE

TEST ONE : -

H_o u = 90°

H_1 u ≠ 90°

n = 47

GROUP B :-

AT 2 MINUTES

$$Z = \frac{97.1 - 90}{\frac{16.7}{\sqrt{47}}} = \frac{7.1}{1.561}$$

$$= 4.55$$

The result is statistically significant at the 1% confidence level of prediction. (<.01 **)

The result is diametrically opposed to that recorded for Group A after two minutes of work.

There is a significant, measurable difference between the model and experimental group. Group B were definitely not sitting with the elbow joint flexed at 90° after two minutes of work.

GROUP B : -

AT 8 MINUTES

$$Z = \frac{97.0 - 90}{\frac{10.8}{\sqrt{47}}} = \frac{7.0}{1.575}$$

$$= 4.444$$

The result is statistically significant at the 1% confidence level of prediction. (<.01 **)

The result is diametrically opposed to that recorded for Group A after two minutes of work.

There is a significant, measurable difference between the model and experimental group B were definitely not sitting with the elbow joint flexed at 90° after eight minutes of work.

CATEGORY : - ELBOW ANGLE

TEST TWO : -

H_0, u at 2 minutes = u at 8 minutes

H_1, u at 2 minutes ≠ u at 8 minutes

$\overline{X}$ = the differences between the model and the measurement of movement (average of 2 minute and 8 minute positions)

Degrees of freedom, N-1 for paired data.

$$Z = \frac{\overline{X} - u}{\frac{S}{\sqrt{n}}}$$

GROUP A : -

AT 2 MINUTES AND 8 MINUTES (AVERAGES)

$$Z = \frac{3.8 - 0}{\frac{2.9}{\sqrt{47}}} = \frac{3.8}{.423}$$

$$= 8.93$$

The result is statistically significant at the 1% confidence level of prediction. (<.01 **)

There is a significant difference between the model and the experimental group; experimental group A were definitely moving and not sitting with the elbow joints flexed at 90° after two minutes and eight minutes of work, respectively.

GROUP B: -

AT 2 MINUTES AND 8 MINUTES (AVERAGES)

$$Z = \frac{7.1 - 0}{\frac{7.2}{\sqrt{47}}} = \frac{7.1}{1.050}$$

$$= 6.76$$

The result is statistically significant at the 1% confidence level of prediction. (<.01 **)

There is a significant difference between the model and the experimental group; experimental group A were difinitely moving and not sitting with the elbow joints flexed at 90° after two minutes and eight minutes of work, respectively.

CATEGORY : - ELBOW ANGLE

TEST THREE :

TO TEST WHETHER OR NOT GROUP A DATA IS SIGNIFICANTLY DIFFERENT TO GROUP B DATA

S = STANDARD DEVIATION

H^O, $u_A = u_B$

H^1, $u_A \neq u_B$

THE TWO SAMPLES ARE STATISTICALLY LARGE NUMBERS

$$. \quad Z = \frac{\bar{X}_A - \bar{X}_B}{\sqrt{\frac{S^2_A}{n_a} + \frac{S^2_B}{n_b}}}$$

2 MINUTE POSITIONS :-

$$Z = \frac{90 - 97.1}{\sqrt{\frac{82.81}{47} + \frac{114.49}{47}}} = \frac{7.1}{2.049}$$

$$= 3.465$$

The result is statistically significant at the 1% confidence level of prediction. (<.01 **)

There is a significant difference between Group A and Group B sitting positions after two minutes of work.

8 MINUTES POSITIONS : -

$$Z = \frac{90.6 - 97.}{\sqrt{\frac{73.96}{47} + \frac{116.64}{47}}} = \frac{6.4}{2.014}$$

$$= 3.177$$

The result is close to the mean expectancy of a normally distributed population.

There is no significant difference between Group A or Group B data at the eight minutes sitting positions.

CATEGORY:- LEFT ULNAR ABDUCTION

STATISTIC :- t- DISTRIBUTION

POPULATION SAMPLE :- NORMAL

SYMMETRY :- SYMMETRICAL;

IT IS REASONABLE TO ASSUME THAT LEFT ULNAR ABDUCTIONS CORRESPOND TO THE STANDARD NORMAL DISTRIBUTION.

MEAN :- CORRESPONDS TO THE STANDARD NORMAL DISTRIBUTION

WHERE :-

- NULL HYPOTHESIS (Ho) POPULATION EQUAL TO 0^{o} (u)
- OR POSITIVE HYPOTHESIS (H_1) POPULATION NOT EQUAL TO 0^{o} (u)
- SAMPLE SIZE (n) = 47
- AVERAGE = ($\bar{x}$)

  APPROXIMATELY NORMAL DUE TO LARGE SAMPLE SIZE.
- STANDARD DEVIATION = S

THERE FORE :-

$$Z = \frac{\bar{X} - u}{\frac{S}{\sqrt{n}}}$$

CATEGORY :- LEFT ULNAR ABDUCTION

STATISTIC : - $\frac{\bar{X} - u}{\frac{S}{\sqrt{n}}}$

TEST ONE : -

H_o u = 90^o

H_1 u ≠ 90^o

n = 47

GROUP A :-

AT 2 MINUTES

$$Z = \frac{5.1 - 0}{\frac{5.0}{\sqrt{47}}} = \frac{5.1}{0.729}$$

$$= 6.99$$

The result is statistically significant at the 1% confidence level of prediction. (<.01 **)

There is a significant difference between the model and the experimental group; experimental group A were definitely moving and not sitting with zero ulnar abduction about the left wrist joint after two minutes of work.

GROUP A : -

AT 8 MINUTES

$$Z = \frac{5.1 - 0}{\frac{4.2}{\sqrt{47}}} = \frac{5.1}{0.6126}$$

$$= 8.325$$

The result is statistically significant at the 1% confidence level of prediction. (<.01 **)

There is a significant difference between the model and the experimental group; experimental group A were definitely moving and not sitting with zero ulnar abduction about the left wrist joint after eight minutes of work.

CATEGORY :- LEFT ULNAR ABDUCTION

TEST ONE : -

H_o u = 90^o

H_1 u $\neq$ 90^o

n = 47

GROUP B :-

AT 2 MINUTES

$$Z = \frac{10.4 - 0}{\frac{5.6}{\sqrt{47}}} = \frac{10.4}{0.817}$$

$$= 12.73$$

The result is statistically significant at the 1% confidence level of prediction. (<.01 **)

There is a significant difference between the model and the experimental group; experimental group B were definitely moving and not sitting with zero ulnar abduction about the left wrist joint after two minutes of work.

GROUP : -

AT 8 MINUTES

$$Z = \frac{11.0}{\frac{5.6}{\sqrt{47}}} = \frac{11.1}{0.7876}$$

$$= 14.09$$

The result is statistically significant at the 1% confidence level of prediction. (<.01 **)

There is a significant difference between the model and the experimental group; experimental group B were definitely moving and not sitting with zero ulnar abduction about the left wrist joint after eight minutes of work.

CATEGORY : - LEFT ULNAR ABDUCTION

TEST TWO : -

H_0, u at 2 minutes = u at 8 minutes

H_1, u at 2 minutes ≠ u at 8 minutes

$\overline{X}$ = the differences between the model and the measurement of movement (average of 2 minute and 8 minute positions)

Degrees of freedom, N-1 for paired data.

$$Z = \frac{\overline{X} - u}{\frac{S}{\sqrt{n}}}$$

GROUP A : -

AT 2 MINUTES AND 8 MINUTES (AVERAGES)

$$Z = \frac{2.3 - 0}{\frac{2.6}{\sqrt{47}}} = \frac{2.3}{0.379}$$

$$= 6.1$$

The result is statistically significant at the 1% confidence level of prediction. (<.01 **)

There is a significant difference between the model and the experimental group; experimental group A were definitely moving and not sitting with zero ulnar abduction about the left wrist joint after two and eight minutes of work, respectively.

GROUP B : -

AT 2 MINUTES AND 8 MINUTES (AVERAGES)

$$Z = \frac{3.3 - 0}{\frac{2.8}{\sqrt{47}}} = \frac{3.3}{0.4084}$$

$$= 8.1$$

The result is statistically significant at the 1% confidence level of prediction. (<.01 **)

There is a significant difference between the model and the experimental group; experimental group B were definitely moving and not sitting with zero ulnar abduction about the left wrist joint after two and eight minutes of work, respectively

CATEGORY : - LEFT ULNAR ABDUCTION

TEST THREE :

TO TEST WHETHER OR NOT GROUP A DATA IS SIGNIFICANTLY DIFFERENT TO GROUP B DATA

S = STANDARD DEVIATION

H^o, $u_A = u_B$

H^1, $u_A \neq u_B$

THE TWO SAMPLES ARE STATISTICALLY LARGE NUMBERS

$$Z = \frac{\bar{X}_A - \bar{X}_B}{\sqrt{\frac{S^2_A}{n_a} + \frac{S^2_B}{n_b}}}$$

2 MINUTE POSITIONS :-

$$Z = \frac{5.1 - 10.4}{\sqrt{\frac{25}{47} + \frac{31.36}{47}}} = \frac{5.3}{1.095} = 4.84$$

The result is statistically significant at the 1% confidence level of prediction. (<.01 **)

There is a significant difference between Group A and Group B ulnar abduction about the left wrist joint after two minutes of work.

8 MINUTES POSITIONS : -

$$Z = \frac{5.1 - 11.1}{\sqrt{\frac{17.64}{47} + \frac{29.16}{47}}} = \frac{6.0}{.987} = 6.07$$

The result is statistically significant at the 1% confidence level of prediction. (<.01 **)

There is a significant difference between Group A and Group B ulnar abduction about the left wrist joint after eight minutes of work.

APPENDICES

APPENDIX H - Separate Histogram Summaries for Experimental Groups A and B, showing the Results for:-

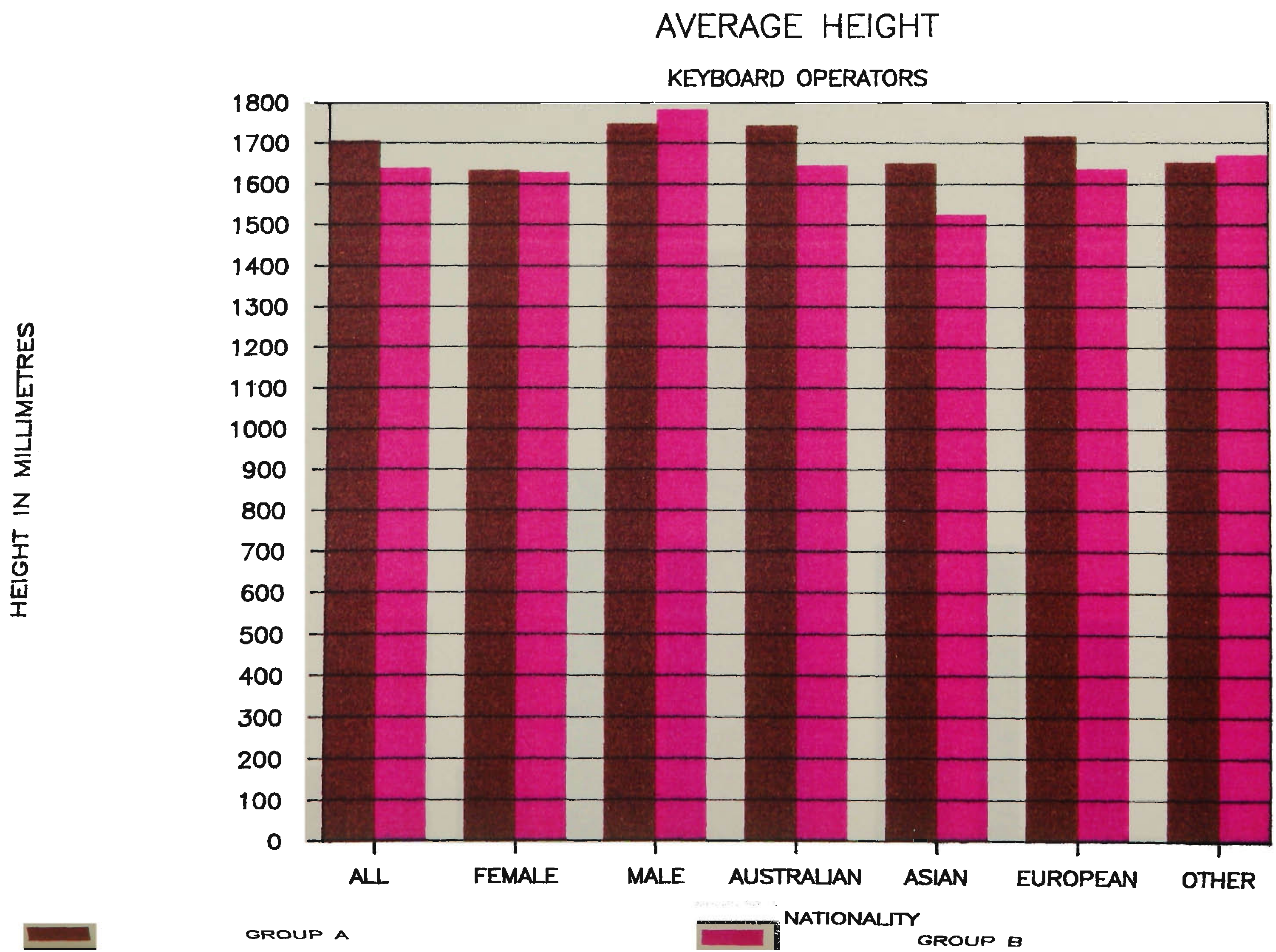
- body stature;
- body mass;
- age;
- sex;
- nationality.

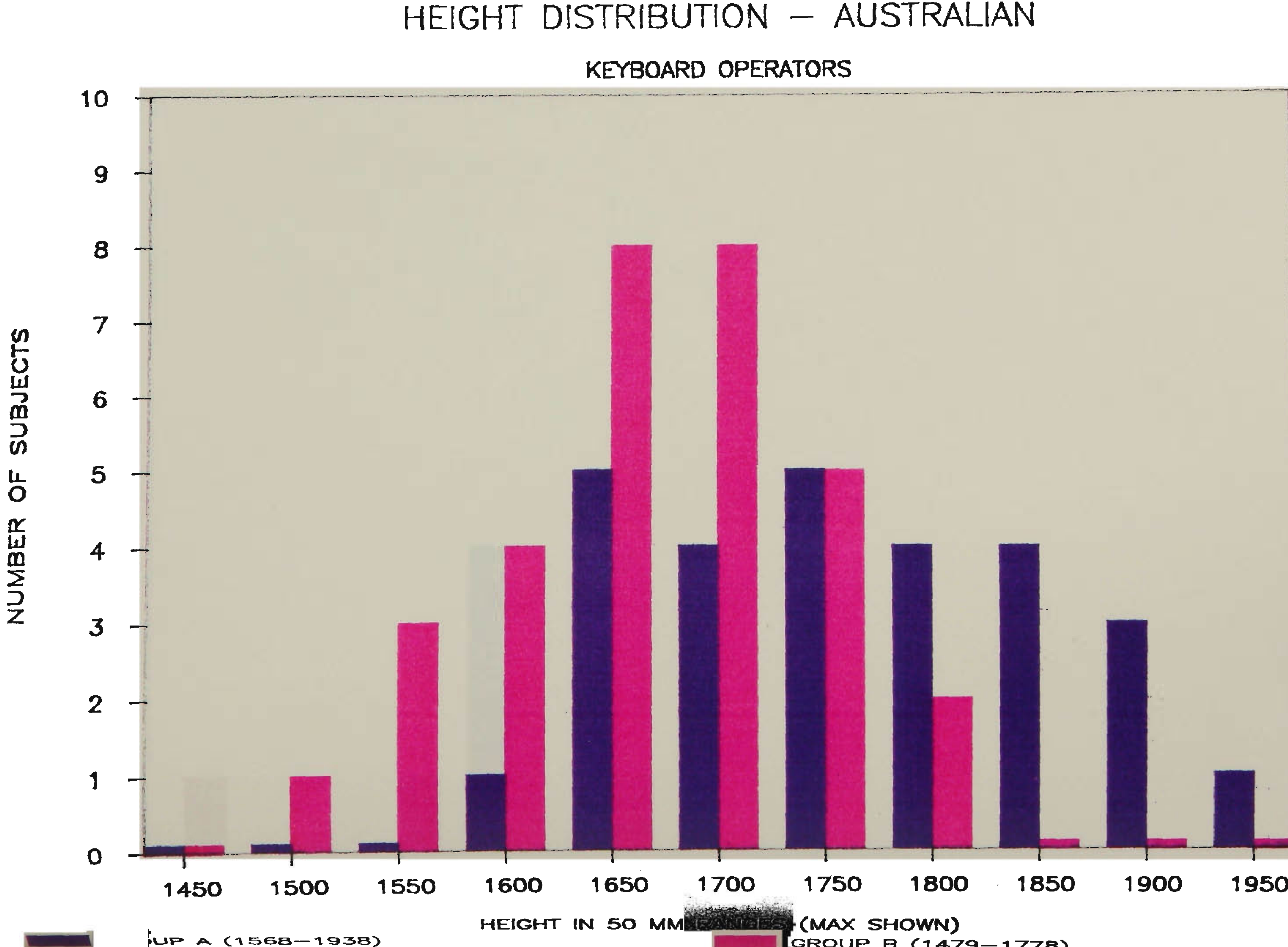
AVERAGES BY SEX AND NATIONALITY

(GRAPHS)

HEIGHT DISTRIBUTION (MILLIMETRES)

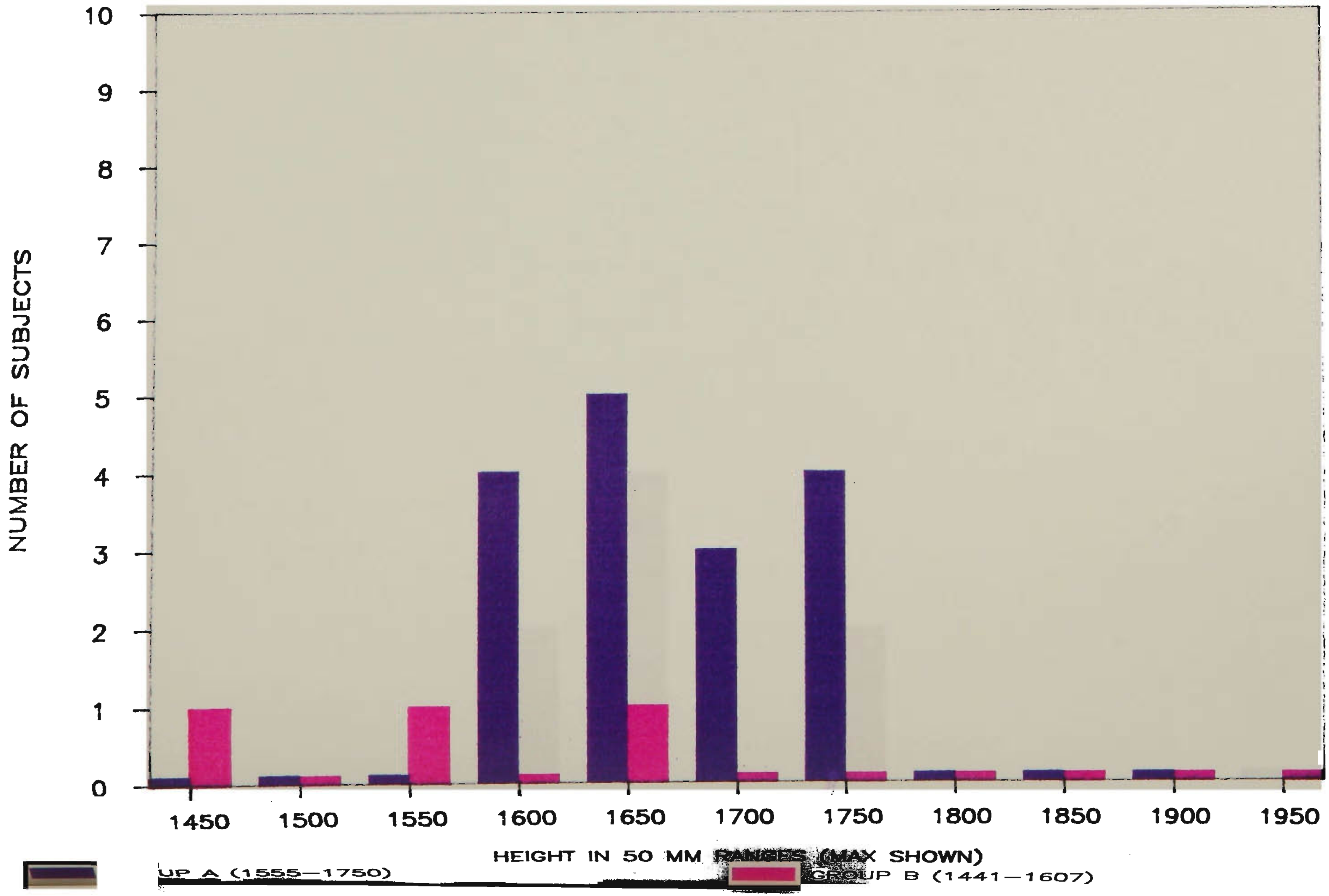
	1401 TO 1450	1451 TO 1500	1501 TO 1550	1551 TO 1600	1601 TO 1650	1651 TO 1700	1701 TO 1750	1751 TO 1800	1801 TO 1850	1851 TO 1900	1901 TO 1950	TOT	MIN	MAX
AUSTRALIAN														
GROUP A	0	0	0	1	5	4	5	4	4	3	1	27	1568	1938
GROUP B	0	1	3	4	8	8	5	2	0	0	0	31	1479	1778
Sub Total	0	1	3	5	13	12	10	6	4	3	1	58	1479	1938
ASIAN														
GROUP A	0	0	0	4	5	3	4	0	0	0	0	16	1555	1750
GROUP B	1	0	1	0	1	0	0	0	0	0	0	3	1441	1607
Sub Total	1	0	1	4	6	3	4	0	0	0	0	19	1441	1750
EUROPEAN														
GROUP A	0	0	0	0	0	1	1	0	0	0	0	2	1683	1747
GROUP B	0	0	0	2	4	0	2	0	0	0	0	8	1568	1734
Sub Total	0	0	0	2	4	1	3	0	0	0	0	10	1568	1747
OTHER														
GROUP A	0	0	0	1	0	0	1	0	0	0	0	2	1570	1734
GROUP B	0	1	0	0	2	0	0	0	2	0	0	5	1479	1811
Sub Total	0	1	0	1	2	0	1	0	2	0	0	7	1479	1811
SUMMARY														
GROUP A	0	0	0	6	10	8	11	4	4	3	1	47	1555	1938
GROUP B	1	3	4	6	15	8	7	2	2	0	0	47	1441	1811
OVERALL	1	3	4	12	25	16	18	6	6	3	1	94	1441	1938


AVERAGE HEIGHT
KEYBOARD OPERATORS
HEIGHT IN MILLIMETRES
1800
1700
1600
1500
1400
1300
1200
1100
1000
900
800
700
600
500
400
300
200
100
0
ALL
FEMALE
MALE
AUSTRALIAN
ASIAN
EUROPEAN
OTHER
NATIONALITY
GROUP A
GROUP B


HEIGHT DISTRIBUTION — AUSTRALIAN
KEYBOARD OPERATORS
NUMBER OF SUBJECTS
0
1
2
3
4
5
6
7
8
9
10
1450
1500
1550
1600
1650
1700
1750
1800
1850
1900
1950
HEIGHT IN 50 MM
(MAX SHOWN)
UP A (1568—1938)
GROUP B (1479—1778)

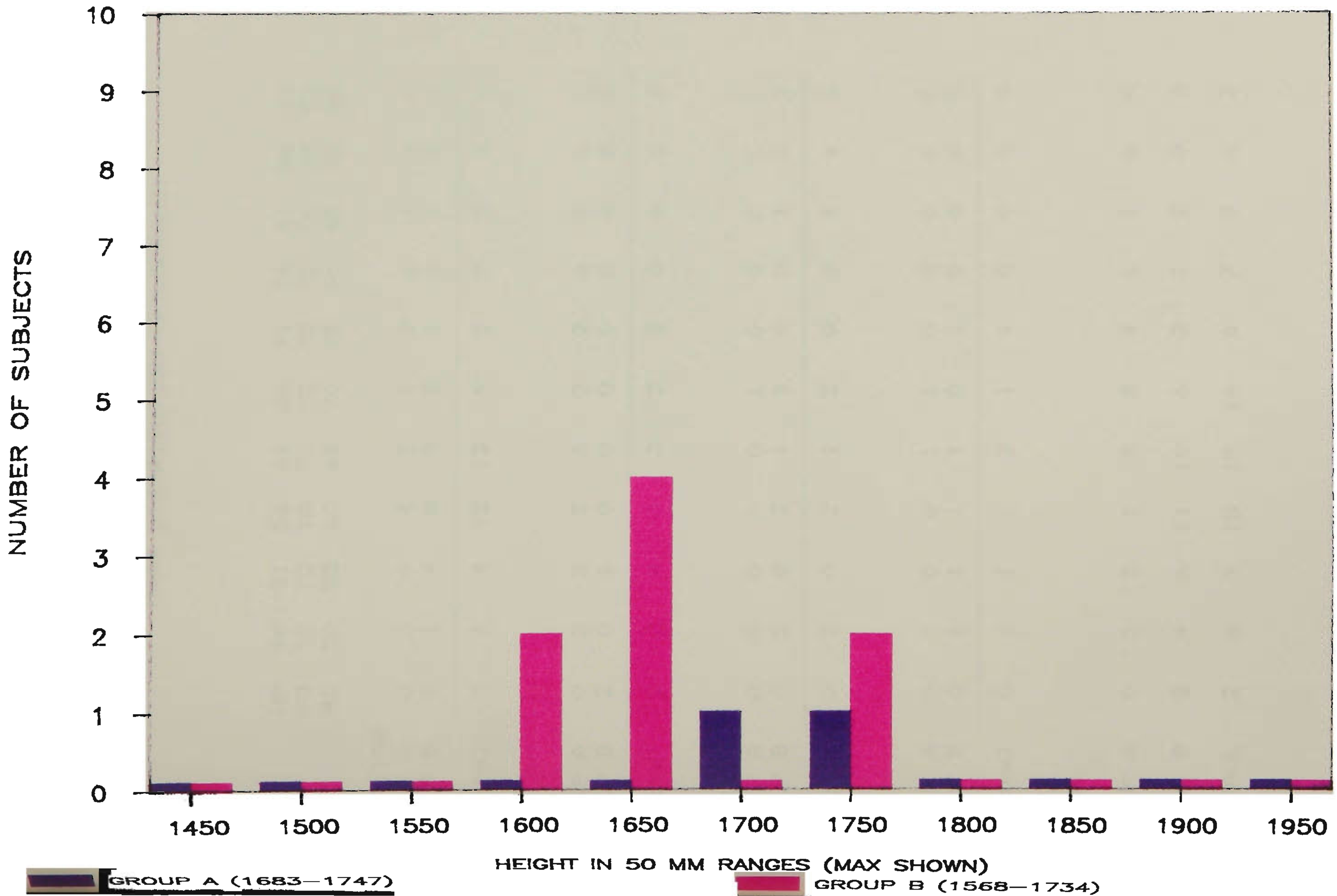
HEIGHT DISTRIBUTION – ASIAN

KEYBOARD OPERATORS



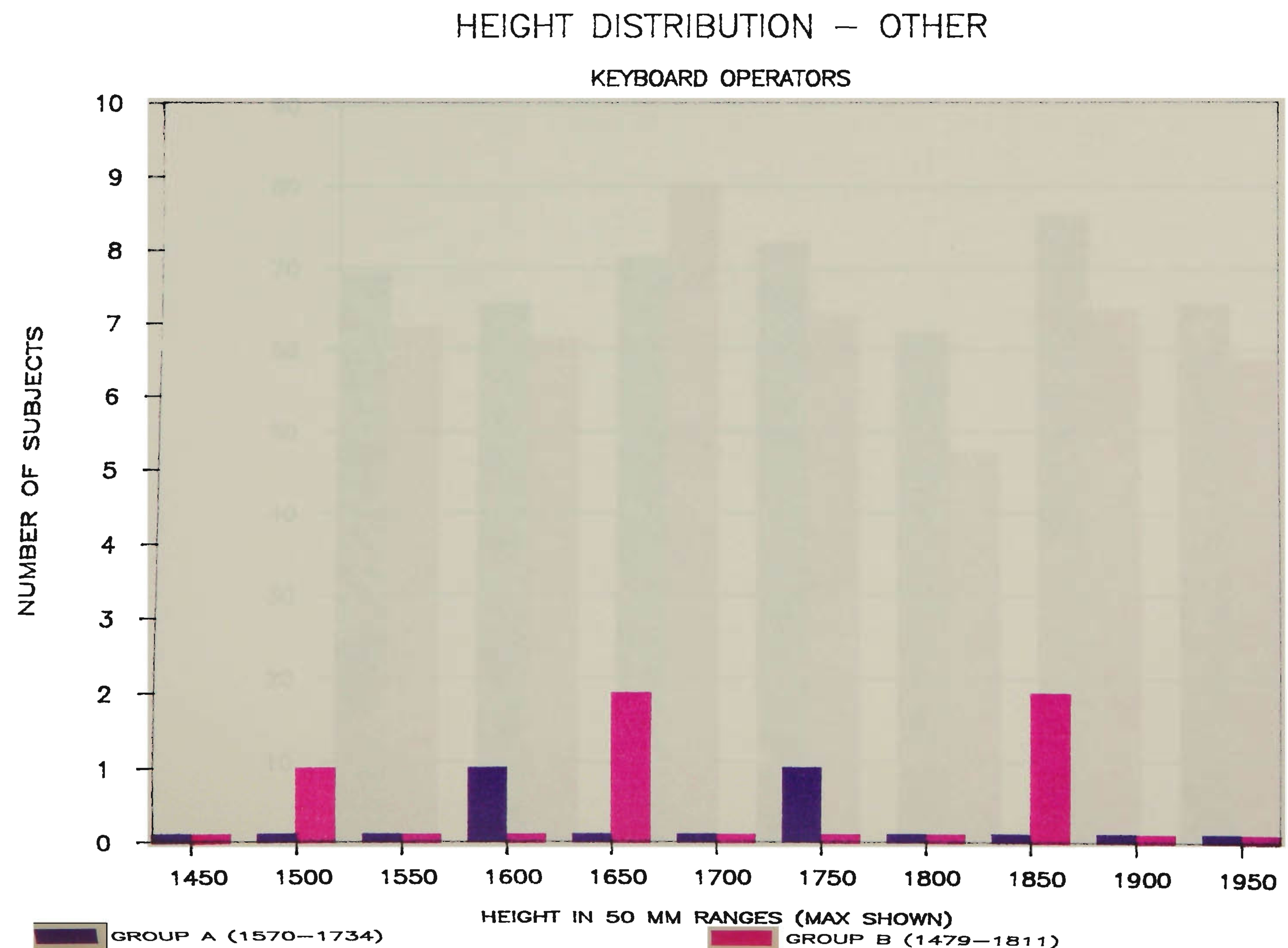
HEIGHT DISTRIBUTION – EUROPEAN

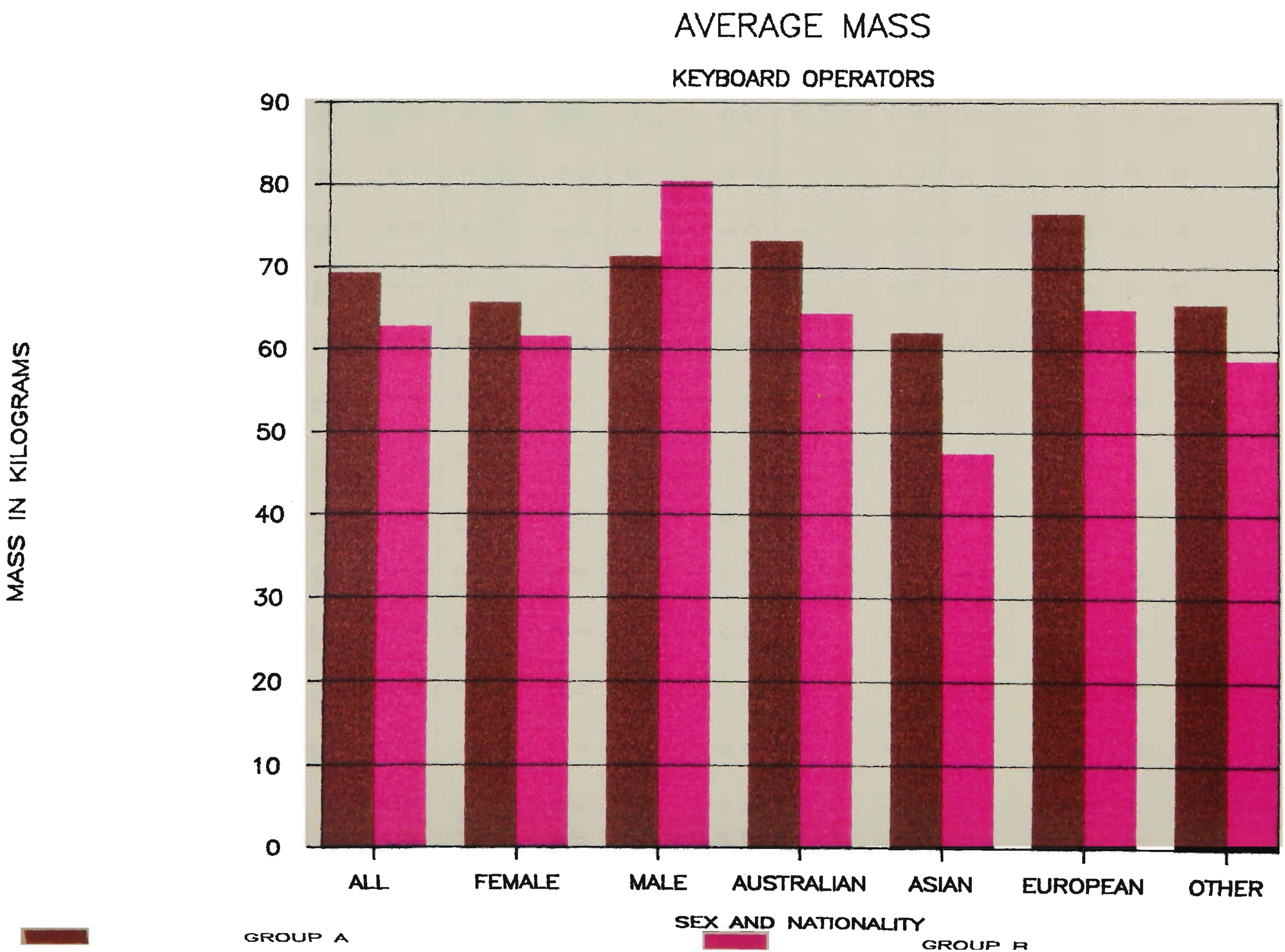
KEYBOARD OPERATORS



MASS DISTRIBUTION (KILOGRAMS)

	UP TO 45	46 TO 50	51 TO 55	56 TO 60	61 TO 65	66 TO 70	71 TO 75	76 TO 80	81 TO 85	86 TO 90	91 TO 95	96 TO 100	101 TO 105	TOT	MIN	MAX
AUSTRALIAN																
GROUP A	0	0	0	4	5	4	2	6	1	4	0	1	0	27	60	100
GROUP B	0	1	4	8	8	5	1	1	1	0	1	0	1	31	46	105
Sub Total	0	1	4	12	13	9	3	7	2	4	1	1	1	58	46	105
ASIAN																
GROUP A	0	2	3	3	3	2	2	0	0	1	0	0	0	16	49	86
GROUP B	2	0	1	0	0	0	0	0	0	0	0	0	0	3	45	52
Sub Total	2	2	4	3	3	2	2	0	0	1	0	0	0	19	45	86
EUROPEAN																
GROUP A	0	0	0	0	0	1	0	0	0	1	0	0	0	2	67	86
GROUP B	0	2	0	2	1	1	0	0	1	0	1	0	0	8	48	92
Sub Total	0	2	0	2	1	2	0	0	1	1	1	0	0	10	48	92
OTHER																
GROUP A	0	0	0	0	1	1	0	0	0	0	0	0	0	2	61	70
GROUP B	0	1	1	1	1	0	1	0	0	0	0	0	0	5	50	73
Sub Total	0	1	1	1	2	1	1	0	0	0	0	0	0	7	50	73
SUMMARY																
GROUP A	0	2	3	7	9	8	4	6	1	6	0	1	0	47	49	100
GROUP B	2	4	6	11	10	6	2	1	2	0	2	0	1	47	45	105
OVERALL	2	6	9	18	19	14	6	7	3	6	2	1	1	93	45	105

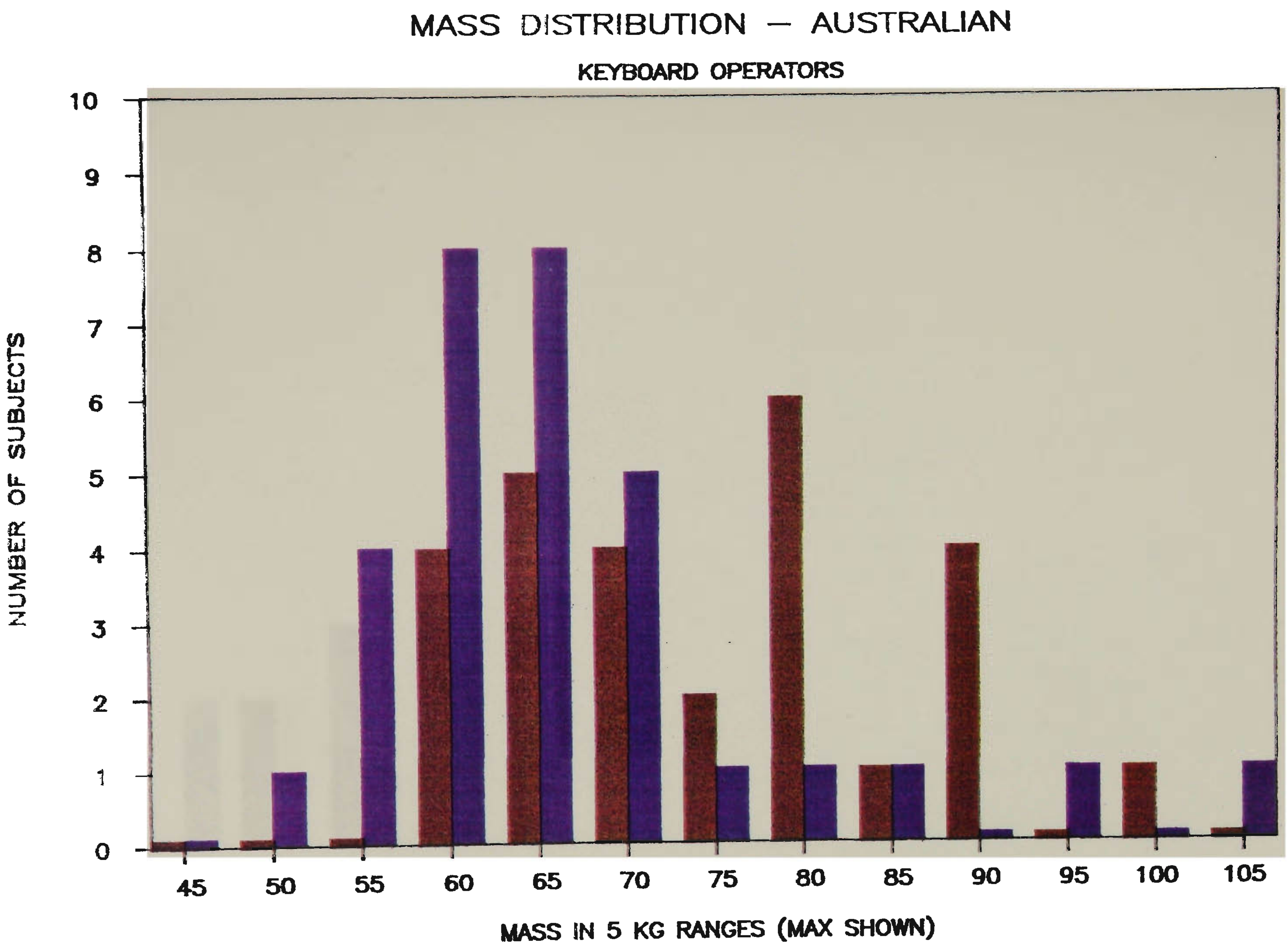

HEIGHT DISTRIBUTION – OTHER
KEYBOARD OPERATORS
NUMBER OF SUBJECTS
0
1
2
3
4
5
6
7
8
9
10
1450
1500
1550
1600
1650
1700
1750
1800
1850
1900
1950
HEIGHT IN 50 MM RANGES (MAX SHOWN)
GROUP A (1570–1734)
GROUP B (1479–1811)



AVERAGE MASS
KEYBOARD OPERATORS
MASS IN KILOGRAMS
90
80
70
60
50
40
30
20
10
0
ALL
FEMALE
MALE
AUSTRALIAN
ASIAN
EUROPEAN
OTHER
SEX AND NATIONALITY
GROUP A
GROUP B

MASS DISTRIBUTION (KILOGRAMS)

	UP TO 45	46 TO 50	51 TO 55	56 TO 60	61 TO 65	66 TO 70	71 TO 75	76 TO 80	81 TO 85	86 TO 90	91 TO 95	96 TO 100	101 TO 105	TOT	MIN	MAX
AUSTRALIAN																
GROUP A	0	0	0	4	5	4	2	6	1	4	0	1	0	27	60	100
GROUP B	0	1	4	8	8	5	1	1	1	0	1	0	1	31	46	105
Sub Total	0	1	4	12	13	9	3	7	2	4	1	1	1	58	46	105
ASIAN																
GROUP A	0	2	3	3	3	2	2	0	0	1	0	0	0	16	49	86
GROUP B	2	0	1	0	0	0	0	0	0	0	0	0	0	3	45	52
Sub Total	2	2	4	3	3	2	2	0	0	1	0	0	0	19	45	86
EUROPEAN																
GROUP A	0	0	0	0	0	1	0	0	0	1	0	0	0	2	67	86
GROUP B	0	2	0	2	1	1	0	0	1	0	1	0	0	8	48	92
Sub Total	0	2	0	2	1	2	0	0	1	1	1	0	0	10	48	92
OTHER																
GROUP A	0	0	0	0	1	1	0	0	0	0	0	0	0	2	61	70
GROUP B	0	1	1	1	1	0	1	0	0	0	0	0	0	5	50	73
Sub Total	0	1	1	1	2	1	1	0	0	0	0	0	0	7	50	73
SUMMARY																
GROUP A	0	2	3	7	9	8	4	6	1	6	0	1	0	47	49	100
GROUP B	2	4	6	11	10	6	2	1	2	0	2	0	1	47	45	105
OVERALL	2	6	9	18	19	14	6	7	3	6	2	1	1	93	45	105



MASS DISTRIBUTION – AUSTRALIAN
KEYBOARD OPERATORS
NUMBER OF SUBJECTS
0
1
2
3
4
5
6
7
8
9
10
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55
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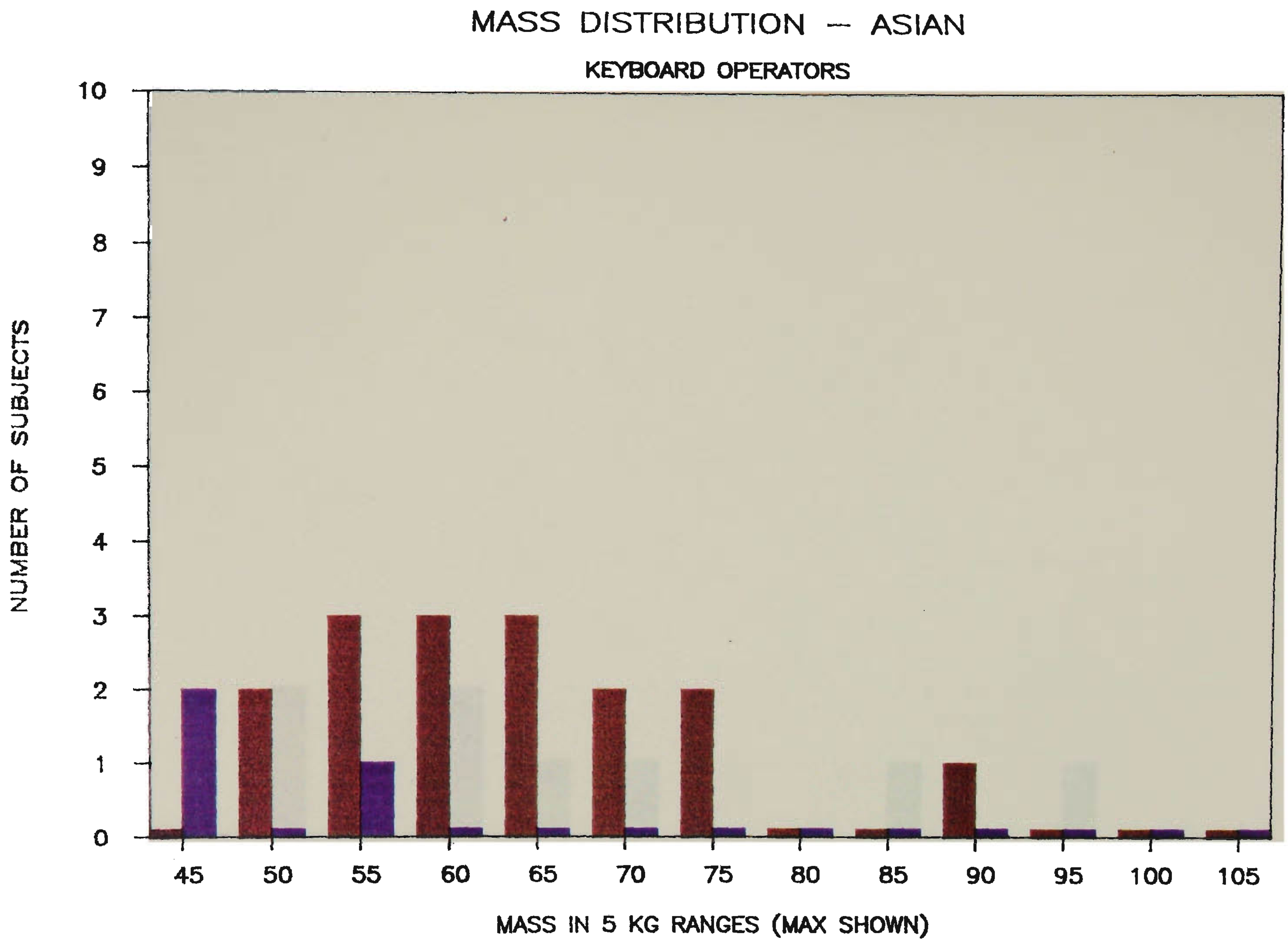
65
70
75
80
85
90
95
100
105
MASS IN 5 KG RANGES (MAX SHOWN)


MASS DISTRIBUTION — ASIAN
KEYBOARD OPERATORS
NUMBER OF SUBJECTS
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3
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5
6
7
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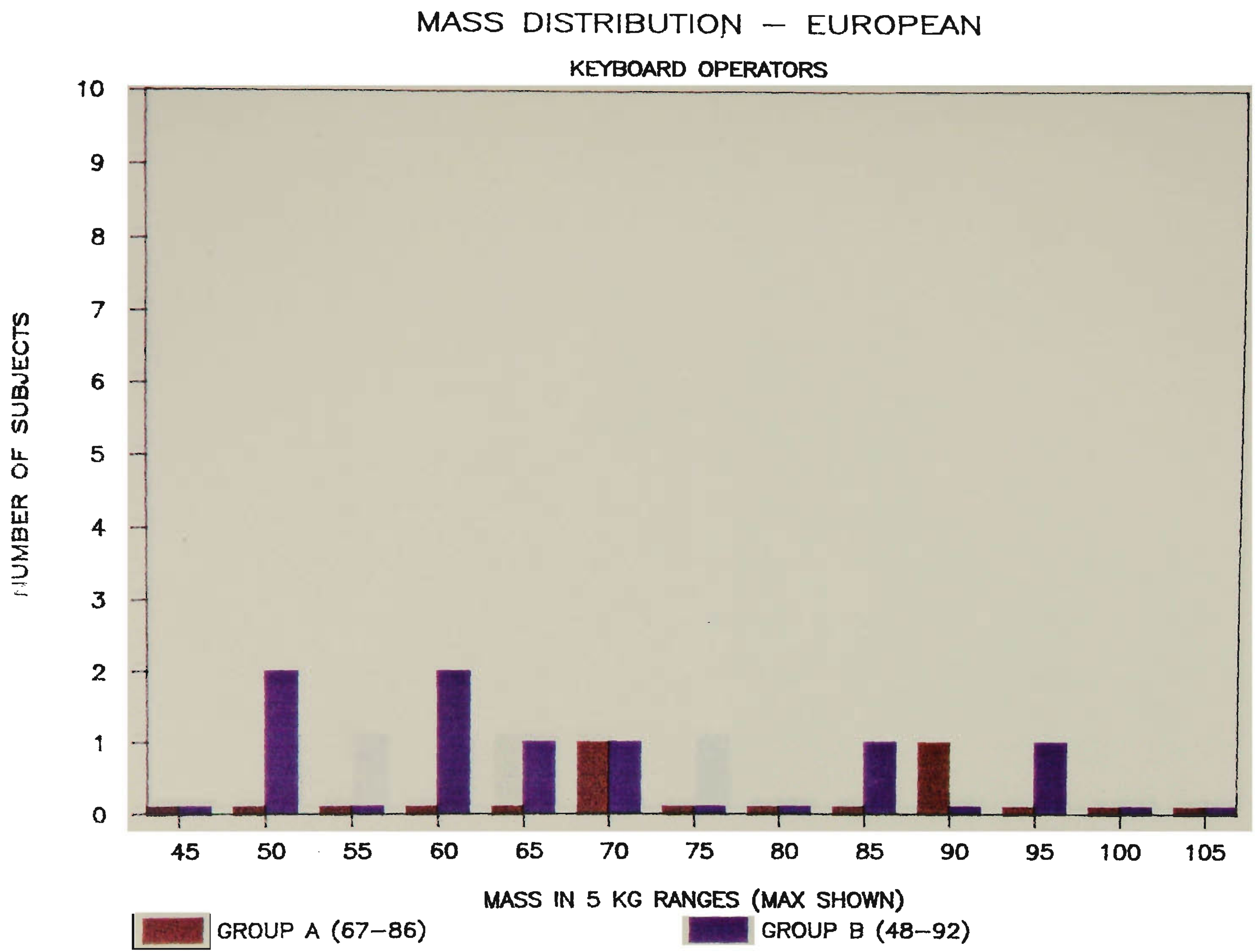
60
65
70
75
80
85
90
95
100
105
MASS IN 5 KG RANGES (MAX SHOWN)


MASS DISTRIBUTION — EUROPEAN
KEYBOARD OPERATORS
NUMBER OF SUBJECTS
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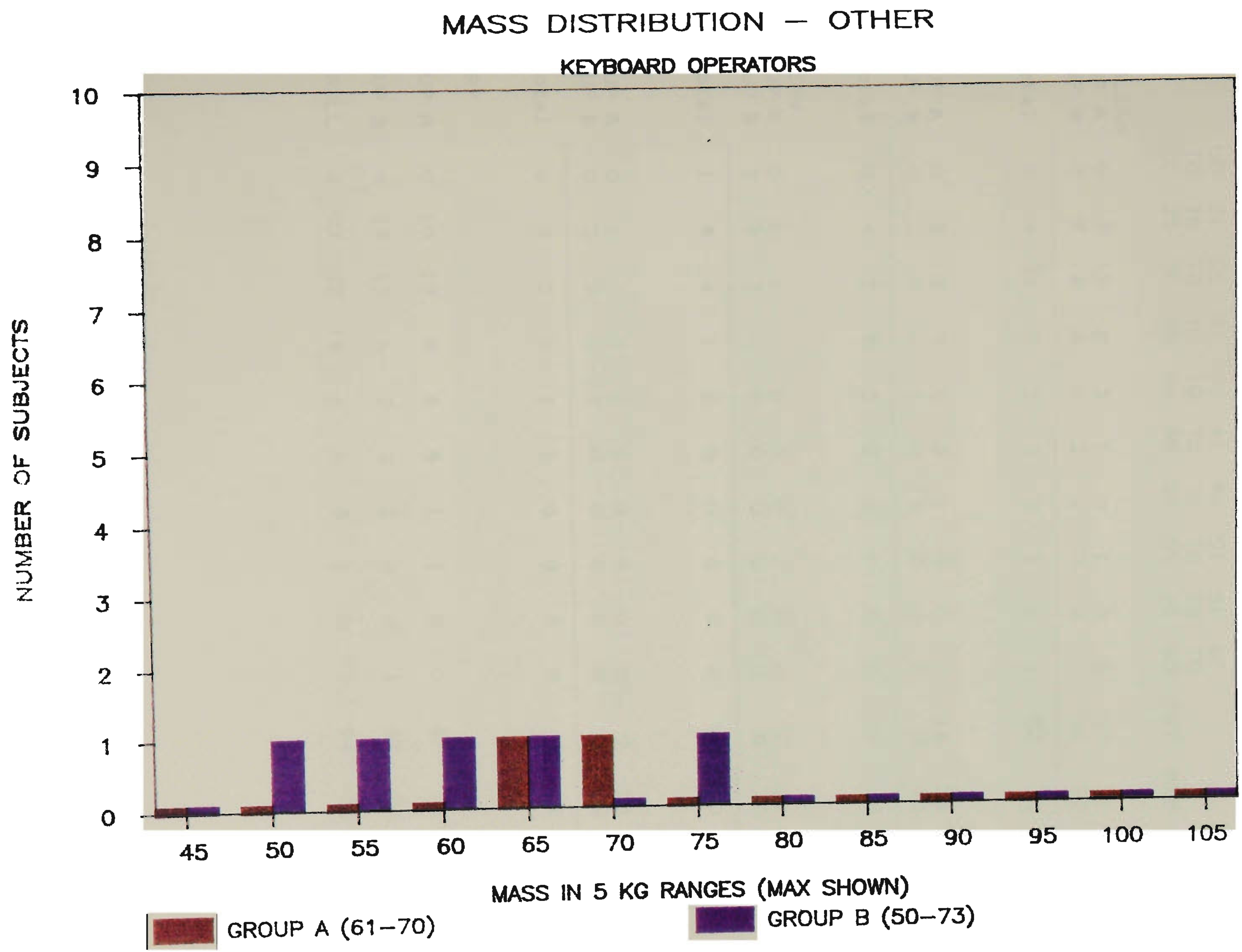
1
2
3
4
5
6
7
8
9
10
45
50
55
60
65
70
75
80
85
90
95
100
105
MASS IN 5 KG RANGES (MAX SHOWN)
GROUP A (67–86)
GROUP B (48–92)



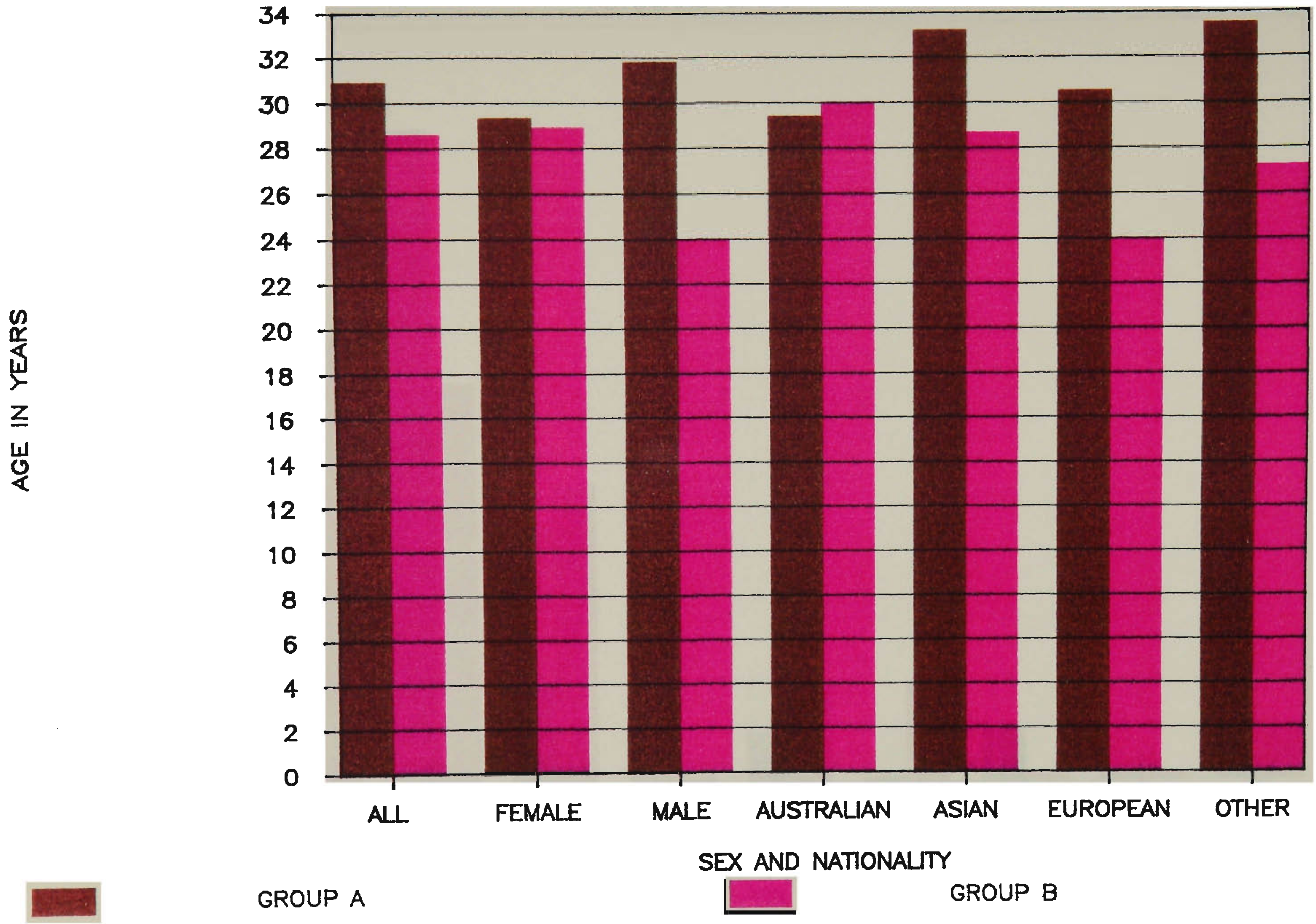
MASS DISTRIBUTION – OTHER
KEYBOARD OPERATORS
NUMBER OF SUBJECTS
0
1
2
3
4
5
6
7
8
9
10
45
50
55
60
65
70
75
80
85
90
95
100
105
MASS IN 5 KG RANGES (MAX SHOWN)
GROUP A (61–70)
GROUP B (50–73)

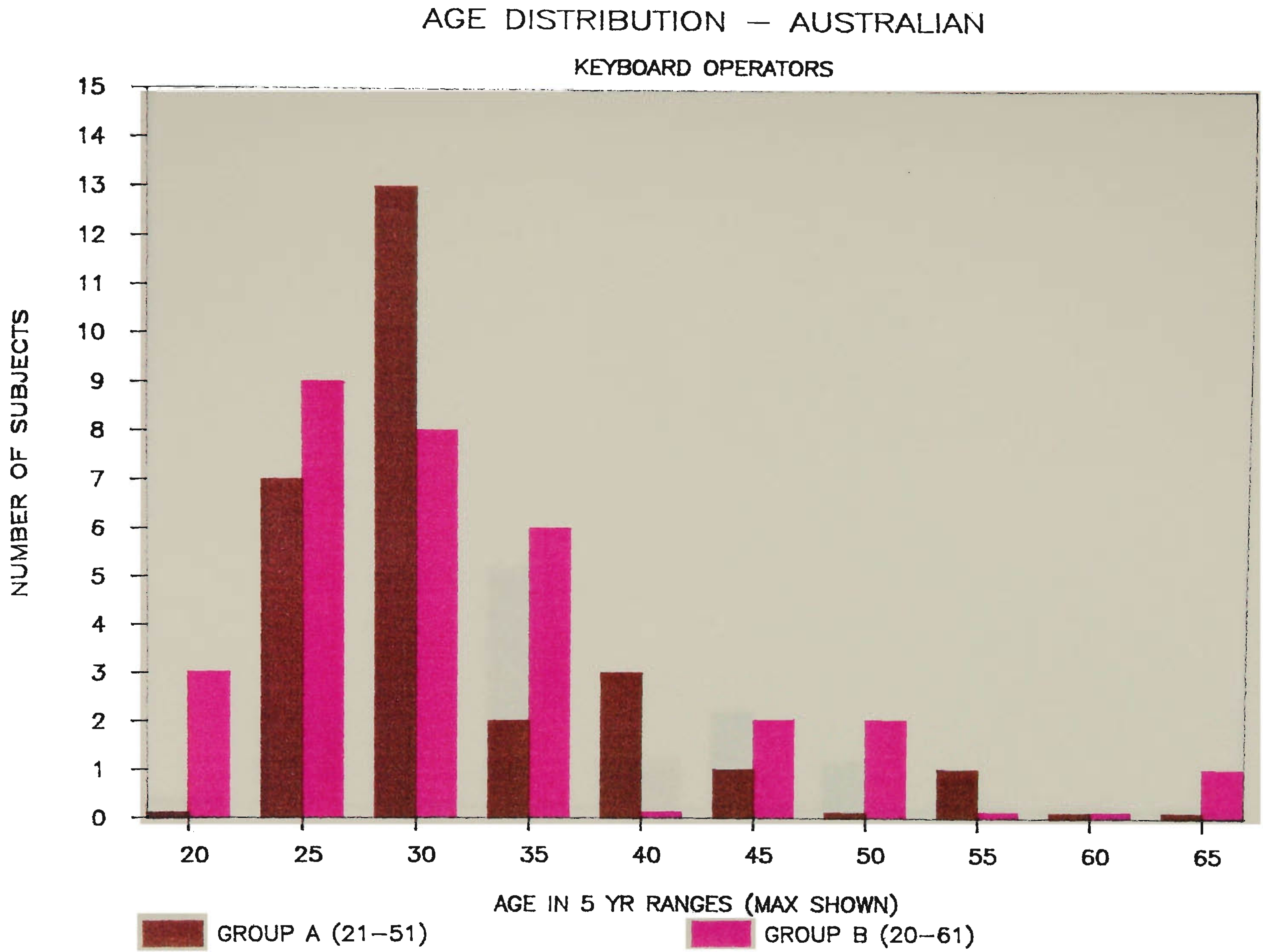
AGE DISTRIBUTION (YEARS)

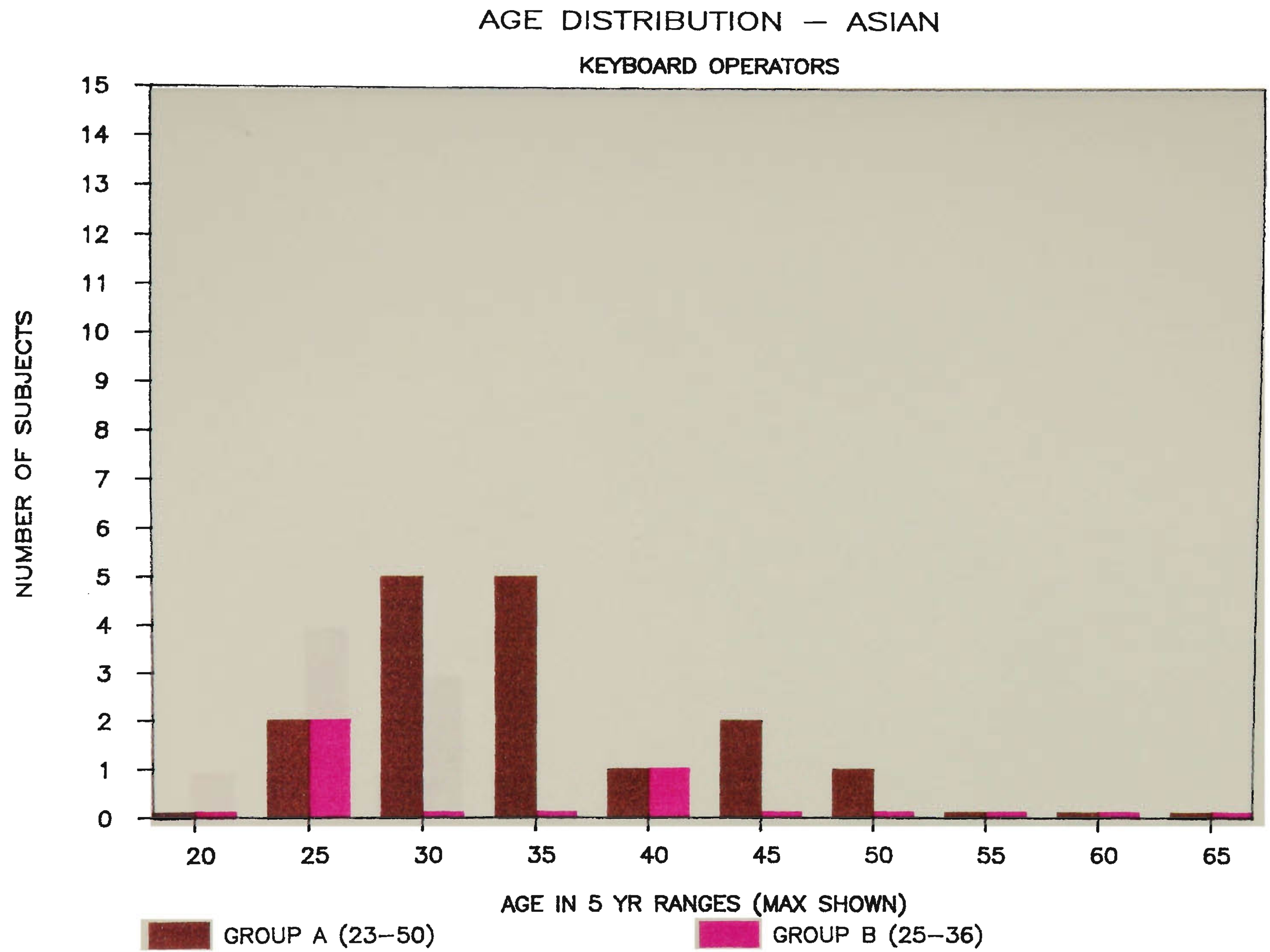
	UP TO 20	21 TO 25	26 TO 30	31 TO 35	36 TO 40	41 TO 45	46 TO 50	51 TO 55	56 TO 60	61 TO 65	TOT	MIN	MAX
AUSTRALIAN													
GROUP A	0	7	13	2	3	1	0	1	0	0	27	21	51
GROUP B	3	9	8	6	0	2	2	0	0	1	31	20	61
Sub Total	3	16	21	8	3	3	2	1	0	1	58	20	61
ASIAN													
GROUP A	0	2	5	5	1	2	1	0	0	0	16	23	50
GROUP B	0	2	0	0	1	0	0	0	0	0	3	25	36
Sub Total	0	4	5	5	2	2	1	0	0	0	19	23	50
EUROPEAN													
GROUP A	0	0	1	1	0	0	0	0	0	0	2	26	35
GROUP B	1	4	3	0	0	0	0	0	0	0	8	20	28
Sub Total	1	4	4	1	0	0	0	0	0	0	10	20	35
OTHER													
GROUP A	0	1	0	0	0	1	0	0	0	0	2	25	42
GROUP B	0	2	2	0	1	0	0	0	0	0	5	22	36
Sub Total	0	3	2	0	1	1	0	0	0	0	7	22	42
SUMMARY													
GROUP A	0	10	19	8	4	4	1	1	0	0	47	21	51
GROUP B	4	17	13	6	2	2	2	0	0	1	47	20	61
OVERALL	4	27	32	14	6	6	3	1	0	1	94	20	61

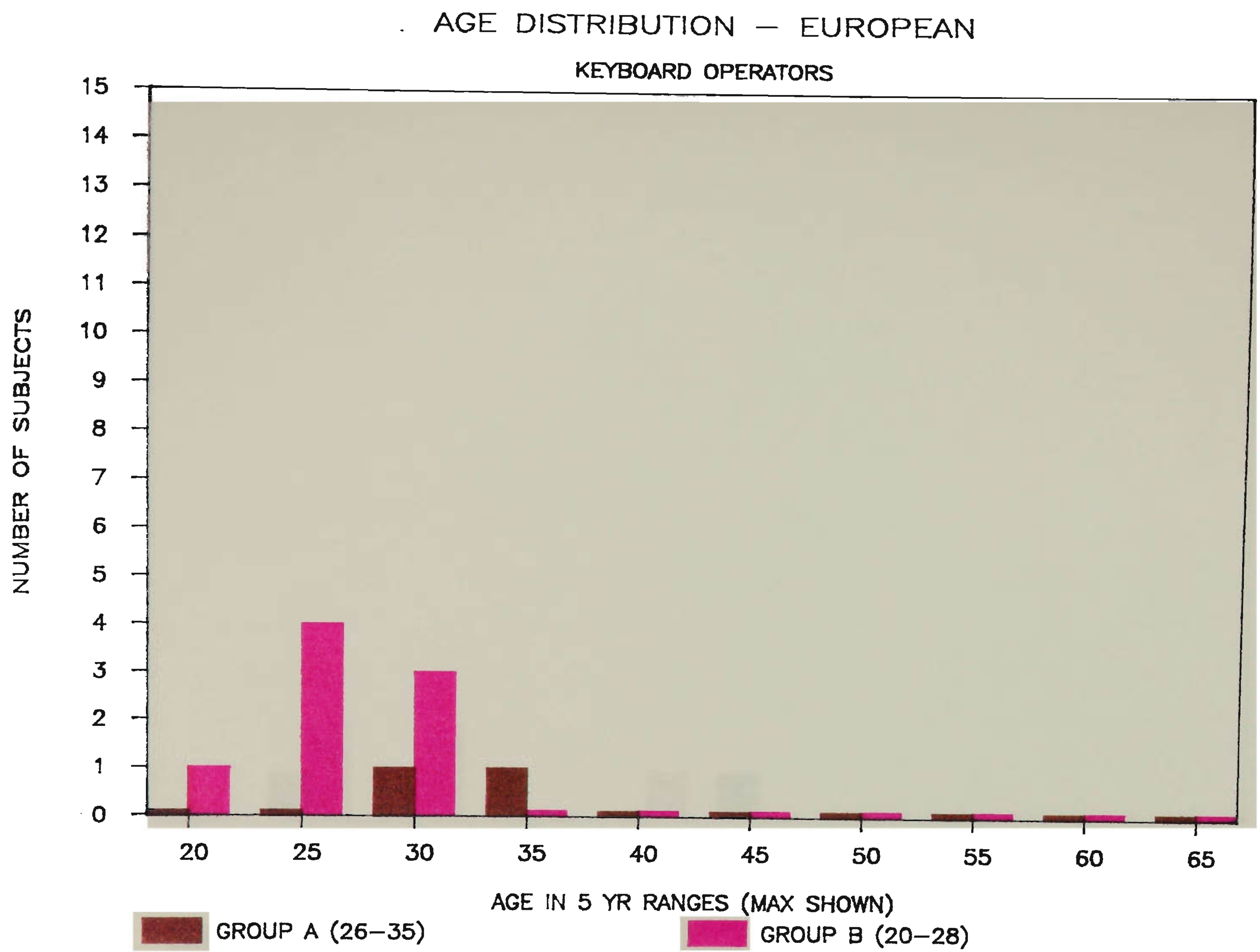
AVERAGE AGE

KEYBOARD OPERATORS



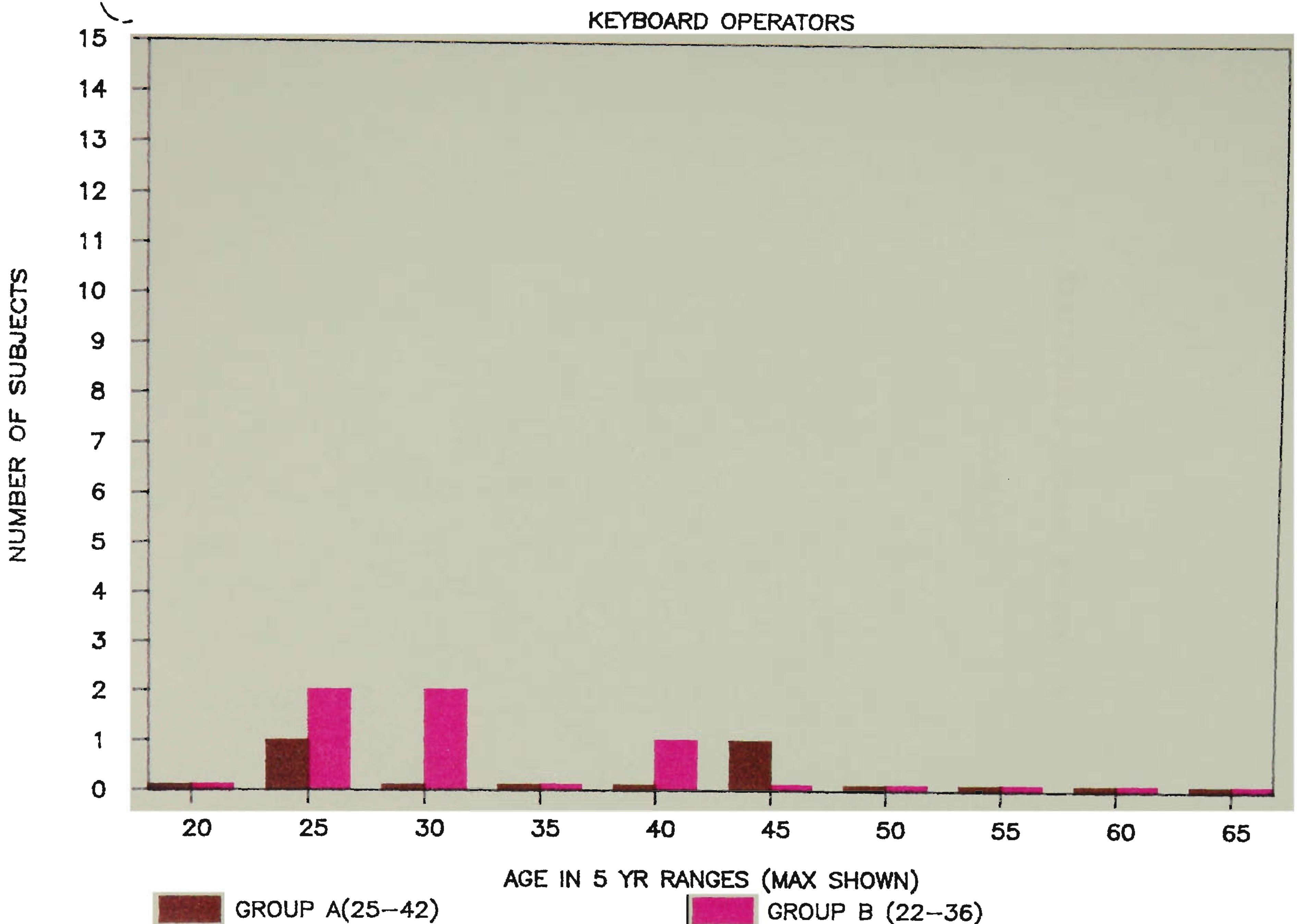

AGE DISTRIBUTION – AUSTRALIAN
KEYBOARD OPERATORS
NUMBER OF SUBJECTS
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
20
25
30
35
40
45
50
55
60
65
AGE IN 5 YR RANGES (MAX SHOWN)
GROUP A (21–51)
GROUP B (20–61)


AGE DISTRIBUTION — ASIAN
KEYBOARD OPERATORS
NUMBER OF SUBJECTS
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
20
25
30
35
40
45
50
55
60
65
AGE IN 5 YR RANGES (MAX SHOWN)
GROUP A (23–50)
GROUP B (25–36)



AGE DISTRIBUTION – EUROPEAN
KEYBOARD OPERATORS
NUMBER OF SUBJECTS
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
20
25
30
35
40
45
50
55
60
65
AGE IN 5 YR RANGES (MAX SHOWN)
GROUP A (26–35)
GROUP B (20–28)

AGE DISTRIBUTION — OTHER



STATISTICAL SUMMARY BY SEX - A

(TABLES)

EXPERIMENTAL GROUP - A (OVERALL)
SAMPLE SIZE - 47

	AGE	HGHT	MASS	EYE/FLOOR DISTANCE 2 MIN	8 MIN	MOVEMEN
MINIMUM	21	1555	49.0	1178	1180	0
MAXIMUM	51	1938	100.0	1300	1285	75
AVERAGE	31	1706	69.2	1240	1241	10
STD DEV	7.2	92.6	11.8	28.5	22.8	13.2
VARIANCE	52	8578	139	810	519	173

EXPERIMENTAL GROUP - A (FEMALE)
SAMPLE SIZE - 17

	AGE	HGHT	MASS	EYE/FLOOR DISTANCE 2 MIN	8 MIN	MOVEMEN
MINIMUM	21	1555	49.0	1178	1180	0
MAXIMUM	42	1747	89.0	1290	1285	75
AVERAGE	29	1633	65.6	1228	1236	10
STD DEV	5.9	54.0	10.5	29.2	25.1	17.1
VARIANCE	35	2912	111	854	629	294

EXPERIMENTAL GROUP - A (MALE)
SAMPLE SIZE - 30

	AGE	HGHT	MASS	EYE/FLOOR DISTANCE 2 MIN	8 MIN	MOVEMEN
MINIMUM	22	1600	50.0	1208	1207	0
MAXIMUM	51	1938	100.0	1300	1285	49
AVERAGE	32	1748	71.3	1247	1244	10
STD DEV	7.7	83.8	12.0	25.5	20.8	10.3
VARIANCE	60	7029	144	651	431	105

EXPERIMENTAL GROUP - A (OVERALL)
SAMPLE SIZE - 47

	AGE	HGHT	MASS	ACROMION/KEYBOARD DISTANCE 2 MIN	8 MIN	MOVEMEN
MINIMUM	21	1555	49.0	178	184	0
MAXIMUM	51	1938	100.0	323	321	32
AVERAGE	31	1706	69.2	244	245	11
STD DEV	7.2	92.6	11.8	34.7	32.3	8.4
VARIANCE	52	8578	139	1207	1042	70

EXPERIMENTAL GROUP - A (FEMALE)
SAMPLE SIZE - 17

	AGE	HGHT	MASS	ACROMION/KEYBOARD DISTANCE 2 MIN	8 MIN	MOVEMEN
MINIMUM	21	1555	49.0	178	195	0
MAXIMUM	42	1747	89.0	310	285	27
AVERAGE	29	1633	65.6	232	232	11.1
STD DEV	5.9	54.0	10.5	31.4	23.7	8.1
VARIANCE	35	2912	111	988	563	65

EXPERIMENTAL GROUP - A (MALE)
SAMPLE SIZE - 30

	AGE	HGHT	MASS	ACROMION/KEYBOARD DISTANCE 2 MIN	8 MIN	MOVEMEN
MINIMUM	22	1600	50.0	182	184	0
MAXIMUM	51	1938	100.0	323	321	32
AVERAGE	32	1748	71.3	251	253	11
STD DEV	7.7	83.8	12.0	34.7	34.0	8.5
VARIANCE	60	7029	144	1205	1154	73

EXPERIMENTAL GROUP - A (OVERALL)
SAMPLE SIZE - 47

	AGE	HGHT	MASS	EYE/COPY DISTANCE 2 MIN	8 MIN	MOVEMEN
MINIMUM	21	1555	49.0	550	552	0
MAXIMUM	51	1938	100.0	787	800	78
AVERAGE	31	1706	69.2	670	671	17
STD DEV	7.2	92.6	11.8	50.6	52.2	18.3
VARIANCE	52	8578	139	2564	2728	334

EXPERIMENTAL GROUP - A (FEMALE)
SAMPLE SIZE - 17

	AGE	HGHT	MASS	EYE/COPY DISTANCE 2 MIN	8 MIN	MOVEMEN
MINIMUM	21	1555	49.0	570	552	0
MAXIMUM	42	1747	89.0	787	740	78
AVERAGE	29	1633	65.6	671	663	22.8
STD DEV	5.9	54.0	10.5	45.0	47.2	22.5
VARIANCE	35	2912	111	2024	2231	507

EXPERIMENTAL GROUP - A (MALE)
SAMPLE SIZE - 30

	AGE	HGHT	MASS	EYE/COPY DISTANCE 2 MIN	8 MIN	MOVEMEN
MINIMUM	22	1600	50.0	550	555	0
MAXIMUM	51	1938	100.0	784	800	72
AVERAGE	32	1748	71.3	670	675	14
STD DEV	7.7	83.8	12.0	53.6	54.4	14.4
VARIANCE	60	7029	144	2869	2958	208

EXPERIMENTAL GROUP - A (OVERALL)
SAMPLE SIZE - 47

	AGE	HGHT	MASS	TRUNK INCLINATION 2 MIN	8 MIN	MOVEMEN
MINIMUM	21	1555	49.0	88.0	89.0	0.0
MAXIMUM	51	1938	100.0	130.0	129.0	27.0
AVERAGE	31	1706	69.2	108.9	110.1	5.5
STD DEV	7.2	92.6	11.8	10.1	10.3	5.5
VARIANCE	52	8578	139	102	106	30

EXPERIMENTAL GROUP - A (FEMALE)
SAMPLE SIZE - 17

	AGE	HGHT	MASS	TRUNK INCLINATION 2 MIN	8 MIN	MOVEMEN
MINIMUM	21	1555	49.0	88.0	92.5	0.0
MAXIMUM	42	1747	89.0	128.0	124.0	20.0
AVERAGE	29	1633	65.6	106.5	110.6	6.5
STD DEV	5.9	54.0	10.5	9.6	8.0	4.9
VARIANCE	35	2912	111	92	65	24

EXPERIMENTAL GROUP - A (MALE)
SAMPLE SIZE - 30

	AGE	HGHT	MASS	TRUNK INCLINATION 2 MIN	8 MIN	MOVEMEN
MINIMUM	22	1600	50.0	89.0	89.0	0.0
MAXIMUM	51	1938	100.0	130.0	129.0	27.0
AVERAGE	32	1748	71.3	110.3	109.8	4.9
STD DEV	7.7	83.8	12.0	10.2	11.3	5.7
VARIANCE	60	7029	144	103	129	33

EXPERIMENTAL GROUP - A (OVERALL)
SAMPLE SIZE - 47

	AGE	HGHT	MASS	HEAD INCLINATION 2 MIN	8 MIN	MOVEMEN
MINIMUM	21	1555	49.0	27.0	25.0	0.0
MAXIMUM	51	1938	100.0	60.0	62.0	26.0
AVERAGE	31	1706	69.2	43.0	43.6	6.4
STD DEV	7.2	92.6	11.8	9.1	9.4	4.9
VARIANCE	52	8578	139	82	88	24

EXPERIMENTAL GROUP - A (FEMALE)
SAMPLE SIZE - 17

	AGE	HGHT	MASS	HEAD INCLINATION 2 MIN	8 MIN	MOVEMEN
MINIMUM	21	1555	49.0	27.5	27.0	0.0
MAXIMUM	42	1747	89.0	55.0	57.0	26.0
AVERAGE	29	1633	65.6	42.1	40.3	6.9
STD DEV	5.9	54.0	10.5	9.6	9.1	6.7
VARIANCE	35	2912	111	93	83	45

EXPERIMENTAL GROUP - A (MALE)
SAMPLE SIZE - 30

	AGE	HGHT	MASS	HEAD INCLINATION 2 MIN	8 MIN	MOVEMEN
MINIMUM	22	1600	50.0	27.0	25.0	1.5
MAXIMUM	51	1938	100.0	60.0	62.0	16.0
AVERAGE	32	1748	71.3	43.6	45.5	6.1
STD DEV	7.7	83.8	12.0	8.7	9.0	3.5
VARIANCE	60	7029	144	76	81	13

EXPERIMENTAL GROUP - A (OVERALL)
SAMPLE SIZE - 47

	AGE	HGHT	MASS	ARM FLEXION 2 MIN	8 MIN	MOVEMEN
MINIMUM	21	1555	49.0	91.0	92.0	0.0
MAXIMUM	51	1938	100.0	132.0	132.0	22.0
AVERAGE	31	1706	69.2	105.3	106.6	4.8
STD DEV	7.2	92.6	11.8	7.8	8.3	4.1
VARIANCE	52	8578	139	62	68	17

EXPERIMENTAL GROUP - A (FEMALE)
SAMPLE SIZE - 17

	AGE	HGHT	MASS	ARM FLEXION 2 MIN	8 MIN	MOVEMEN
MINIMUM	21	1555	49.0	95.5	93.5	0.0
MAXIMUM	42	1747	89.0	132.0	122.0	10.0
AVERAGE	29	1633	65.6	105.7	105.0	3.7
STD DEV	5.9	54.0	10.5	8.3	7.4	2.8
VARIANCE	35	2912	111	69	55	8

EXPERIMENTAL GROUP - A (MALE)
SAMPLE SIZE - 30

	AGE	HGHT	MASS	ARM FLEXION 2 MIN	8 MIN	MOVEMEN
MINIMUM	22	1600	50.0	91.0	92.0	0.0
MAXIMUM	51	1938	100.0	123.0	132.0	22.0
AVERAGE	32	1748	71.3	105.0	107.5	5.5
STD DEV	7.7	83.8	12.0	7.5	8.6	4.6
VARIANCE	60	7029	144	57	73	21

EXPERIMENTAL GROUP - A (OVERALL)
SAMPLE SIZE - 47

	AGE	HGHT	MASS	ARM ABDUCTION 2 MIN	8 MIN	MOVEMEN
MINIMUM	21	1555	49.0	10.0	13.5	0.0
MAXIMUM	51	1938	100.0	37.0	36.5	11.5
AVERAGE	31	1706	69.2	23.6	24.0	2.9
STD DEV	7.2	92.6	11.8	6.8	6.2	2.9
VARIANCE	52	8578	139	46	38	8

EXPERIMENTAL GROUP - A (FEMALE)
SAMPLE SIZE - 17

	AGE	HGHT	MASS	ARM ABDUCTION 2 MIN	8 MIN	MOVEMEN
MINIMUM	21	1555	49.0	15.0	15.0	0.0
MAXIMUM	42	1747	89.0	33.0	36.5	11.5
AVERAGE	29	1633	65.6	22.4	22.1	4.4
STD DEV	5.9	54.0	10.5	5.0	5.0	3.1
VARIANCE	35	2912	111	25	25	10

EXPERIMENTAL GROUP - A (MALE)
SAMPLE SIZE - 30

	AGE	HGHT	MASS	ARM ABDUCTION 2 MIN	8 MIN	MOVEMEN
MINIMUM	22	1600	50.0	10.0	13.5	0.0
MAXIMUM	51	1938	100.0	37.0	36.5	10.0
AVERAGE	32	1748	71.3	24.3	25.1	2.0
STD DEV	7.7	83.8	12.0	7.5	6.5	2.4
VARIANCE	60	7029	144	56	42	6

EXPERIMENTAL GROUP - A (OVERALL)
SAMPLE SIZE - 47

	AGE	HGHT	MASS	ELBOW ANGLE 2 MIN	8 MIN	MOVEMEN
MINIMUM	21	1555	49.0	73.0	72.5	0.0
MAXIMUM	51	1938	100.0	111.0	110.0	12.0
AVERAGE	31	1706	69.2	90.0	90.6	3.8
STD DEV	7.2	92.6	11.8	9.1	8.6	2.9
VARIANCE	52	8578	139	82	74	8

EXPERIMENTAL GROUP - A (FEMALE)
SAMPLE SIZE - 17

	AGE	HGHT	MASS	ELBOW ANGLE 2 MIN	8 MIN	MOVEMEN
MINIMUM	21	1555	49.0	73.0	80.0	0.0
MAXIMUM	42	1747	89.0	111.0	99.0	12.0
AVERAGE	29	1633	65.6	89.3	89.3	5.0
STD DEV	5.9	54.0	10.5	8.7	5.8	3.5
VARIANCE	35	2912	111	75	33	12

EXPERIMENTAL GROUP - A (MALE)
SAMPLE SIZE - 30

	AGE	HGHT	MASS	ELBOW ANGLE 2 MIN	8 MIN	MOVEMEN
MINIMUM	22	1600	50.0	75.5	72.5	0.0
MAXIMUM	51	1938	100.0	106.5	110.0	9.5
AVERAGE	32	1748	71.3	90.5	91.3	3.1
STD DEV	7.7	83.8	12.0	9.3	9.7	2.2
VARIANCE	60	7029	144	86	95	5

EXPERIMENTAL GROUP - A (OVERALL)
SAMPLE SIZE - 47

	AGE	HGHT	MASS	LEFT ULNAR ABDUCTION 2 MIN	8 MIN	MOVEMEN
MINIMUM	21	1555	49.0	0.0	0.0	0.0
MAXIMUM	51	1938	100.0	23.0	16.5	12.0
AVERAGE	31	1706	69.2	5.1	5.1	2.3
STD DEV	7.2	92.6	11.8	5.0	4.2	2.6
VARIANCE	52	8578	139	25	17	7

EXPERIMENTAL GROUP - A (FEMALE)
SAMPLE SIZE - 17

	AGE	HGHT	MASS	LEFT ULNAR ABDUCTION 2 MIN	8 MIN	MOVEMEN
MINIMUM	21	1555	49.0	0.0	0.0	0.0
MAXIMUM	42	1747	89.0	19.5	12.0	12.0
AVERAGE	29	1633	65.6	5.2	5.5	2.8
STD DEV	5.9	54.0	10.5	4.3	3.8	2.9
VARIANCE	35	2912	111	18	14	8

EXPERIMENTAL GROUP - A (MALE)
SAMPLE SIZE - 30

	AGE	HGHT	MASS	LEFT ULNAR ABDUCTION 2 MIN	8 MIN	MOVEMEN
MINIMUM	22	1600	50.0	0.0	0.0	0.0
MAXIMUM	51	1938	100.0	23.0	16.5	10.5
AVERAGE	32	1748	71.3	5.0	4.9	2.0
STD DEV	7.7	83.8	12.0	5.4	4.3	2.4
VARIANCE	60	7029	144	29	19	6

STATISTICAL SUMMARY BY SEX - B

(TABLES)

EXPERIMENTAL GROUP - B (OVERALL)
SAMPLE SIZE - 47

	AGE	HGHT	MASS	EYE/FLOOR DISTANCE 2 MIN	8 MIN	MOVEMEN
MINIMUM	20	1441	45.0	1005	1010	0
MAXIMUM	61	1811	105.0	1680	1640	100
AVERAGE	29	1637	62.8	1213	1219	26
STD DEV	8.1	82.8	12.4	159.5	165.8	27.0
VARIANCE	65	6864	153	25433	27492	728

EXPERIMENTAL GROUP - B (FEMALE)
SAMPLE SIZE - 44

	AGE	HGHT	MASS	EYE/FLOOR DISTANCE 2 MIN	8 MIN	MOVEMEN
MINIMUM	20	1441	45.0	1005	1010	0
MAXIMUM	61	1811	92.0	1680	1640	100
AVERAGE	29	1628	61.6	1217	1225	26
STD DEV	8.2	76.1	10.9	163.7	169.8	27.4
VARIANCE	68	5785	119	26783	28844	751

EXPERIMENTAL GROUP - B (MALE)
SAMPLE SIZE - 3

	AGE	HGHT	MASS	EYE/FLOOR DISTANCE 2 MIN	8 MIN	MOVEMEN
MINIMUM	20	1755	63.0	1115	1128	2
MAXIMUM	27	1811	105.0	1178	1138	50
AVERAGE	24	1781	80.3	1144	1135	25
STD DEV	2.9	23.0	17.9	25.9	4.7	19.6
VARIANCE	9	528	321	671	22	386

EXPERIMENTAL GROUP - B (OVERALL)
SAMPLE SIZE - 47

	AGE	HGHT	MASS	ACROMION/KEYBOARD DISTANCE 2 MIN	8 MIN	MOVEMEN
MINIMUM	20	1441	45.0	201	183	0
MAXIMUM	61	1811	105.0	330	332	50
AVERAGE	29	1637	62.8	262	261	12
STD DEV	8.1	82.8	12.4	29.2	28.8	9.9
VARIANCE	65	6864	153	853	828	99

EXPERIMENTAL GROUP - B (FEMALE)
SAMPLE SIZE - 44

	AGE	HGHT	MASS	ACROMION/KEYBOARD DISTANCE 2 MIN	8 MIN	MOVEMEN
MINIMUM	20	1441	45.0	201	183	0
MAXIMUM	61	1811	92.0	330	332	50
AVERAGE	29	1628	61.6	261	260	12
STD DEV	8.2	76.1	10.9	29.7	29.3	10.1
VARIANCE	68	5785	119	884	861	103

EXPERIMENTAL GROUP - B (MALE)
SAMPLE SIZE - 3

	AGE	HGHT	MASS	ACROMION/KEYBOARD DISTANCE 2 MIN	8 MIN	MOVEMEN
MINIMUM	20	1755	63.0	251	248	3
MAXIMUM	27	1811	105.0	290	283	10
AVERAGE	24	1781	80.3	273	270	6
STD DEV	2.9	23.0	17.9	16.2	15.8	2.9
VARIANCE	9	528	321	263	251	8

EXPERIMENTAL GROUP - B (OVERALL)
SAMPLE SIZE - 47

	AGE	HGHT	MASS	EYE/COPY DISTANCE 2 MIN	8 MIN	MOVEMEN
MINIMUM	20	1441	45.0	478	488	0
MAXIMUM	61	1811	105.0	850	876	93
AVERAGE	29	1637	62.8	700	707	26
STD DEV	8.1	82.8	12.4	77.4	87.0	21.3
VARIANCE	65	6864	153	5992	7568	455

EXPERIMENTAL GROUP - B (FEMALE)
SAMPLE SIZE - 44

	AGE	HGHT	MASS	EYE/COPY DISTANCE 2 MIN	8 MIN	MOVEMEN
MINIMUM	20	1441	45.0	478	488	0
MAXIMUM	61	1811	92.0	850	876	86
AVERAGE	29	1628	61.6	700	708	24
STD DEV	8.2	76.1	10.9	79.3	88.9	19.2
VARIANCE	68	5785	119	6293	7910	369

EXPERIMENTAL GROUP - B (MALE)
SAMPLE SIZE - 3

	AGE	HGHT	MASS	EYE/COPY DISTANCE 2 MIN	8 MIN	MOVEMEN
MINIMUM	20	1755	63.0	648	645	39
MAXIMUM	27	1811	105.0	738	765	93
AVERAGE	24	1781	80.3	704	699	57
STD DEV	2.9	23.0	17.9	39.7	49.7	25.2
VARIANCE	9	528	321	1578	2472	636

EXPERIMENTAL GROUP - B (OVERALL)
SAMPLE SIZE - 47

	AGE	HGHT	MASS	TRUNK INCLINATION 2 MIN	8 MIN	MOVEMEN
MINIMUM	20	1441	45.0	74	75.0	0.0
MAXIMUM	61	1811	105.0	125	124.5	22.5
AVERAGE	29	1637	62.8	107	107.6	6.9
STD DEV	8.1	82.8	12.4	10.7	11.0	5.4
VARIANCE	65	6864	153	114	121	29

EXPERIMENTAL GROUP - B (FEMALE)
SAMPLE SIZE - 44

	AGE	HGHT	MASS	TRUNK INCLINATION 2 MIN	8 MIN	MOVEMEN
MINIMUM	20	1441	45.0	74.0	75.0	0.0
MAXIMUM	61	1811	92.0	125.0	124.5	22.5
AVERAGE	29	1628	61.6	106.7	107.7	6.8
STD DEV	8.2	76.1	10.9	10.9	11.2	5.4
VARIANCE	68	5785	119	119	126	29

EXPERIMENTAL GROUP - B (MALE)
SAMPLE SIZE - 3

	AGE	HGHT	MASS	TRUNK INCLINATION 2 MIN	8 MIN	MOVEMEN
MINIMUM	20	1755	63.0	113.0	101.5	1.5
MAXIMUM	27	1811	105.0	114.0	114.5	12.5
AVERAGE	24	1781	80.3	113.3	105.8	8.5
STD DEV	2.9	23.0	17.9	0.5	6.1	5.0
VARIANCE	9	528	321	0	38	25

EXPERIMENTAL GROUP - B (OVERALL)
SAMPLE SIZE - 47

	AGE	HGHT	MASS	HEAD INCLINATION 2 MIN	8 MIN	MOVEMEN
MINIMUM	20	1441	45.0	20.0	14.0	0.0
MAXIMUM	61	1811	105.0	51.0	57.0	21.5
AVERAGE	29	1637	62.8	32.2	30.3	6.2
STD DEV	8.1	82.8	12.4	6.2	9.4	5.1
VARIANCE	65	6864	153	38	89	26

EXPERIMENTAL GROUP - B (FEMALE)
SAMPLE SIZE - 44

	AGE	HGHT	MASS	HEAD INCLINATION 2 MIN	8 MIN	MOVEMEN
MINIMUM	20	1441	45.0	20.0	14.0	0.0
MAXIMUM	61	1811	92.0	51.0	57.0	21.5
AVERAGE	29	1628	61.6	32.2	29.3	5.7
STD DEV	8.2	76.1	10.9	6.2	8.6	4.7
VARIANCE	68	5785	119	39	75	22

EXPERIMENTAL GROUP - B (MALE)
SAMPLE SIZE - 3

	AGE	HGHT	MASS	HEAD INCLINATION 2 MIN	8 MIN	MOVEMEN
MINIMUM	20	1755	63.0	27.5	37.0	7.0
MAXIMUM	27	1811	105.0	38.5	53.0	19.5
AVERAGE	24	1781	80.3	32.0	45.7	13.7
STD DEV	2.9	23.0	17.9	4.7	6.6	5.1
VARIANCE	9	528	321	22	44	26

EXPERIMENTAL GROUP - B (OVERALL)
SAMPLE SIZE - 47

	AGE	HGHT	MASS	ARM FLEXION 2 MIN	8 MIN	MOVEMEN
MINIMUM	20	1441	45.0	88.5	91.5	0.0
MAXIMUM	61	1811	105.0	123.0	123.5	27.5
AVERAGE	29	1637	62.8	103.4	103.8	4.4
STD DEV	8.1	82.8	12.4	7.8	7.4	5.1
VARIANCE	65	6864	153	61	54	26

EXPERIMENTAL GROUP - B (FEMALE)
SAMPLE SIZE - 44

	AGE	HGHT	MASS	ARM FLEXION 2 MIN	8 MIN	MOVEMEN
MINIMUM	20	1441	45.0	88.5	91.5	0.0
MAXIMUM	61	1811	92.0	123.0	123.5	27.5
AVERAGE	29	1628	61.6	103.4	103.7	4.2
STD DEV	8.2	76.1	10.9	7.9	7.2	5.0
VARIANCE	68	5785	119	63	52	25

EXPERIMENTAL GROUP - B (MALE)
SAMPLE SIZE - 3

	AGE	HGHT	MASS	ARM FLEXION 2 MIN	8 MIN	MOVEMEN
MINIMUM	20	1755	63.0	97.5	92.0	1.5
MAXIMUM	27	1811	105.0	111.5	111.5	14.0
AVERAGE	24	1781	80.3	103.3	104.5	8.2
STD DEV	2.9	23.0	17.9	5.9	8.9	5.1
VARIANCE	9	528	321	35	79	26

EXPERIMENTAL GROUP - B (OVERALL)
SAMPLE SIZE - 47

	AGE	HGHT	MASS	ARM ABDUCTION 2 MIN	8 MIN	MOVEMEN
MINIMUM	20	1441	45.0	16.5	13.0	0.0
MAXIMUM	61	1811	105.0	40.5	44.0	10.5
AVERAGE	29	1637	62.8	24.9	25.0	4.1
STD DEV	8.1	82.8	12.4	5.8	6.1	2.9
VARIANCE	65	6864	153	34	37	9

EXPERIMENTAL GROUP - B (FEMALE)
SAMPLE SIZE - 44

	AGE	HGHT	MASS	ARM ABDUCTION 2 MIN	8 MIN	MOVEMEN
MINIMUM	20	1441	45.0	16.5	13.0	0.0
MAXIMUM	61	1811	92.0	40.5	44.0	10.5
AVERAGE	29	1628	61.6	24.8	24.8	3.8
STD DEV	8.2	76.1	10.9	5.9	6.0	2.8
VARIANCE	68	5785	119	35	36	8

EXPERIMENTAL GROUP - B (MALE)
SAMPLE SIZE - 3

	AGE	HGHT	MASS	ARM ABDUCTION 2 MIN	8 MIN	MOVEMEN
MINIMUM	20	1755	63.0	21.0	21.5	6.5
MAXIMUM	27	1811	105.0	30.0	37.5	10.0
AVERAGE	24	1781	80.3	26.2	28.8	8.3
STD DEV	2.9	23.0	17.9	3.8	6.6	1.4
VARIANCE	9	528	321	14	44	2

EXPERIMENTAL GROUP - B (OVERALL)
SAMPLE SIZE - 47

	AGE	HGHT	MASS	ELBOW ANGLE 2 MIN	ELBOW ANGLE 8 MIN	ELBOW ANGLE MOVEMEN
MINIMUM	20	1441	45.0	75.0	79.5	0.0
MAXIMUM	61	1811	105.0	120.5	121.5	32.0
AVERAGE	29	1637	62.8	97.1	97.0	7.1
STD DEV	8.1	82.8	12.4	10.7	10.8	7.2
VARIANCE	65	6864	153	115	117	52

EXPERIMENTAL GROUP - B (FEMALE)
SAMPLE SIZE - 44

	AGE	HGHT	MASS	ELBOW ANGLE 2 MIN	ELBOW ANGLE 8 MIN	ELBOW ANGLE MOVEMEN
MINIMUM	20	1441	45.0	75.0	79.5	0.0
MAXIMUM	61	1811	92.0	120.5	121.5	32.0
AVERAGE	29	1628	61.6	96.7	96.8	6.5
STD DEV	8.2	76.1	10.9	10.8	10.5	6.7
VARIANCE	68	5785	119	117	111	45

EXPERIMENTAL GROUP - B (MALE)
SAMPLE SIZE - 3

	AGE	HGHT	MASS	ELBOW ANGLE 2 MIN	ELBOW ANGLE 8 MIN	ELBOW ANGLE MOVEMEN
MINIMUM	20	1755	63.0	93.5	82.5	7.5
MAXIMUM	27	1811	105.0	110.0	116.0	27.5
AVERAGE	24	1781	80.3	102.8	99.8	15.3
STD DEV	2.9	23.0	17.9	6.9	13.7	8.7
VARIANCE	9	528	321	48	188	76

EXPERIMENTAL GROUP - B (OVERALL)
SAMPLE SIZE - 47

	AGE	HGHT	MASS	LEFT ULNAR ABDUCTION 2 MIN	8 MIN	MOVEMEN
MINIMUM	20	1441	45.0	0.0	0.0	0.0
MAXIMUM	61	1811	105.0	32.0	23.5	12.5
AVERAGE	29	1637	62.8	10.4	11.1	3.3
STD DEV	8.1	82.8	12.4	5.6	5.4	2.8
VARIANCE	65	6864	153	31	29	8

EXPERIMENTAL GROUP - B (FEMALE)
SAMPLE SIZE - 44

	AGE	HGHT	MASS	LEFT ULNAR ABDUCTION 2 MIN	8 MIN	MOVEMEN
MINIMUM	20	1441	45.0	0.0	0.0	0.0
MAXIMUM	61	1811	92.0	32.0	23.5	12.5
AVERAGE	29	1628	61.6	10.5	11.4	3.4
STD DEV	8.2	76.1	10.9	5.7	5.3	2.8
VARIANCE	68	5785	119	32	29	8

EXPERIMENTAL GROUP - B (MALE)
SAMPLE SIZE - 3

	AGE	HGHT	MASS	LEFT ULNAR ABDUCTION 2 MIN	8 MIN	MOVEMEN
MINIMUM	20	1755	63.0	5.0	2.5	0.5
MAXIMUM	27	1811	105.0	11.0	11.5	3.5
AVERAGE	24	1781	80.3	8.7	6.8	2.2
STD DEV	2.9	23.0	17.9	2.6	3.7	1.2
VARIANCE	9	528	321	7	14	2

STATISTICAL SUMMARY BY NATIONALITY - A

(TABLES)

EXPERIMENTAL GROUP - A (OVERALL)
SAMPLE SIZE - 47

	AGE	HGHT	MASS	EYE/FLOOR DISTANCE 2 MIN	8 MIN	MOVEMEN
MINIMUM	21	1555	49.0	1178	1180	0
MAXIMUM	51	1938	100.0	1300	1285	75
AVERAGE	31	1706	69.2	1240	1241	10
STD DEV	7.2	92.6	11.8	28.5	22.8	13.2
VARIANCE	52	8578	139	810	519	173

EXPERIMENTAL GROUP - A (AUSTRALIAN
SAMPLE SIZE - 27

	AGE	HGHT	MASS	EYE/FLOOR DISTANCE 2 MIN	8 MIN	MOVEMEN
MINIMUM	21	1568	60.0	1184	1200	0
MAXIMUM	51	1938	100.0	1300	1285	75
AVERAGE	29	1742	73.2	1247	1247	9
STD DEV	7.0	94.0	11.2	26.1	19.6	15.8
VARIANCE	49	8830	125	683	386	250

EXPERIMENTAL GROUP - A (ASIAN)
SAMPLE SIZE - 16

	AGE	HGHT	MASS	EYE/FLOOR DISTANCE 2 MIN	8 MIN	MOVEMEN
MINIMUM	23	1555	49	1190	1206	0
MAXIMUM	50	1750	86	1278	1270	31
AVERAGE	33	1651	62	1226	1230	11
STD DEV	7.0	60.7	9.9	20.6	17.6	8.6
VARIANCE	49	3689	99	424	309	73

EXPERIMENTAL GROUP - A (EUROPEAN)
SAMPLE SIZE - 2

	AGE	HGHT	MASS	EYE/FLOOR DISTANCE 2 MIN	8 MIN	MOVEMEN
MINIMUM	26	1683	67.0	1178	1180	2
MAXIMUM	35	1747	86.0	1290	1285	5
AVERAGE	31	1715	76.5	1234	1233	4
STD DEV	4.5	32.0	9.5	56.0	52.5	1.5
VARIANCE	20	1024	90	3136	2756	2

EXPERIMENTAL GROUP - A (OTHER)
SAMPLE SIZE - 2

	AGE	HGHT	MASS	EYE/FLOOR DISTANCE 2 MIN	8 MIN	MOVEMEN
MINIMUM	25	1570	61.0	1241	1244	3
MAXIMUM	42	1734	70.0	1284	1265	19
AVERAGE	34	1652	65.5	1263	1255	11
STD DEV	8.5	82.0	4.5	21.5	10.5	8.0
VARIANCE	72	6724	20	462	110	64

EXPERIMENTAL GROUP - A (OVERALL)
SAMPLE SIZE - 47

	AGE	HGHT	MASS	ACROMION/KEYBOARD DISTANCE 2 MIN	8 MIN	MOVEMEN
MINIMUM	21	1555	49.0	178	184	0
MAXIMUM	51	1938	100.0	323	321	32
AVERAGE	31	1706	69.2	244	245	11
STD DEV	7.2	92.6	11.8	34.7	32.3	8.4
VARIANCE	52	8578	139	1207	1042	70

EXPERIMENTAL GROUP - A (AUSTRALIAN
SAMPLE SIZE - 27

	AGE	HGHT	MASS	ACROMION/KEYBOARD DISTANCE 2 MIN	8 MIN	MOVEMEN
MINIMUM	21	1568	60.0	190	198	0
MAXIMUM	51	1938	100.0	323	321	32
AVERAGE	29	1742	73.2	255	253	10
STD DEV	7.0	94.0	11.2	31.5	30.9	7.5
VARIANCE	49	8830	125	994	953	56

EXPERIMENTAL GROUP - A (ASIAN)
SAMPLE SIZE - 16

	AGE	HGHT	MASS	ACROMION/KEYBOARD DISTANCE 2 MIN	8 MIN	MOVEMEN
MINIMUM	23	1555	49	178	184	0
MAXIMUM	50	1750	86	284	308	29
AVERAGE	33	1651	62	224	230	13
STD DEV	7.0	60.7	9.9	31.4	31.4	9.6
VARIANCE	49	3689	99	987	985	92

EXPERIMENTAL GROUP - A (EUROPEAN)
SAMPLE SIZE - 2

	AGE	HGHT	MASS	ACROMION/KEYBOARD DISTANCE 2 MIN	8 MIN	MOVEMEN
MINIMUM	26	1683	67.0	225	230	5
MAXIMUM	35	1747	86.0	310	285	25
AVERAGE	31	1715	76.5	268	258	15
STD DEV	4.5	32.0	9.5	42.5	27.5	10.0
VARIANCE	20	1024	90	1806	756	100

EXPERIMENTAL GROUP - A (OTHER)
SAMPLE SIZE - 2

	AGE	HGHT	MASS	ACROMION/KEYBOARD DISTANCE 2 MIN	8 MIN	MOVEMEN
MINIMUM	25	1570	61.0	240	230	10
MAXIMUM	42	1734	70.0	243	255	12
AVERAGE	34	1652	65.5	242	243	11
STD DEV	8.5	82.0	4.5	1.5	12.5	1.0
VARIANCE	72	6724	20	2	156	1

EXPERIMENTAL GROUP - A (OVERALL)
SAMPLE SIZE - 47

	AGE	HGHT	MASS	EYE/COPY DISTANCE 2 MIN	8 MIN	MOVEMEN
MINIMUM	21	1555	49.0	550	552	0
MAXIMUM	51	1938	100.0	787	800	78
AVERAGE	31	1706	69.2	670	671	17
STD DEV	7.2	92.6	11.8	50.6	52.2	18.3
VARIANCE	52	8578	139	2564	2728	334

EXPERIMENTAL GROUP - A (AUSTRALIAN
SAMPLE SIZE - 27

	AGE	HGHT	MASS	EYE/COPY DISTANCE 2 MIN	8 MIN	MOVEMEN
MINIMUM	21	1568	60.0	550	555	0
MAXIMUM	51	1938	100.0	784	800	40
AVERAGE	29	1742	73.2	676	678	12
STD DEV	7.0	94.0	11.2	46.4	49.0	9.9
VARIANCE	49	8830	125	2155	2402	98

EXPERIMENTAL GROUP - A (ASIAN)
SAMPLE SIZE - 16

	AGE	HGHT	MASS	EYE/COPY DISTANCE 2 MIN	8 MIN	MOVEMEN
MINIMUM	23	1555	49	570	552	0
MAXIMUM	50	1750	86	787	740	78
AVERAGE	33	1651	62	655	655	25
STD DEV	7.0	60.7	9.9	53.0	49.2	26.4
VARIANCE	49	3689	99	2810	2423	699

EXPERIMENTAL GROUP - A (EUROPEAN)
SAMPLE SIZE - 2

	AGE	HGHT	MASS	EYE/COPY DISTANCE 2 MIN	8 MIN	MOVEMEN
MINIMUM	26	1683	67.0	650	640	10
MAXIMUM	35	1747	86.0	710	690	20
AVERAGE	31	1715	76.5	680	665	15
STD DEV	4.5	32.0	9.5	30.0	25.0	5.0
VARIANCE	20	1024	90	900	625	25

EXPERIMENTAL GROUP - A (OTHER)
SAMPLE SIZE - 2

	AGE	HGHT	MASS	EYE/COPY DISTANCE 2 MIN	8 MIN	MOVEMEN
MINIMUM	25	1570	61.0	645	620	25
MAXIMUM	42	1734	70.0	770	795	25
AVERAGE	34	1652	65.5	708	708	25
STD DEV	8.5	82.0	4.5	62.5	87.5	0.0
VARIANCE	72	6724	20	3906	7656	0

EXPERIMENTAL GROUP - A (OVERALL)
SAMPLE SIZE - 47

	AGE	HGHT	MASS	TRUNK INCLINATION 2 MIN	8 MIN	MOVEMEN
MINIMUM	21	1555	49.0	88.0	89.0	0.0
MAXIMUM	51	1938	100.0	130.0	129.0	27.0
AVERAGE	31	1706	69.2	108.9	110.1	5.5
STD DEV	7.2	92.6	11.8	10.1	10.3	5.5
VARIANCE	52	8578	139	102	106	30

EXPERIMENTAL GROUP - A (AUSTRALIAN
SAMPLE SIZE - 27

	AGE	HGHT	MASS	TRUNK INCLINATION 2 MIN	8 MIN	MOVEMEN
MINIMUM	21	1568	60.0	88.0	89.0	0.0
MAXIMUM	51	1938	100.0	119.0	123.0	10.0
AVERAGE	29	1742	73.2	106.7	107.7	3.9
STD DEV	7.0	94.0	11.2	9.7	8.9	2.8
VARIANCE	49	8830	125	94	79	8

EXPERIMENTAL GROUP - A (ASIAN)
SAMPLE SIZE - 16

	AGE	HGHT	MASS	TRUNK INCLINATION 2 MIN	8 MIN	MOVEMEN
MINIMUM	23	1555	49	92.0	90.0	0.0
MAXIMUM	50	1750	86	130.0	129.0	27.0
AVERAGE	33	1651	62	111.9	112.9	8.7
STD DEV	7.0	60.7	9.9	10.7	12.3	7.5
VARIANCE	49	3689	99	115	152	57

EXPERIMENTAL GROUP - A (EUROPEAN)
SAMPLE SIZE - 2

	AGE	HGHT	MASS	TRUNK INCLINATION 2 MIN	8 MIN	MOVEMEN
MINIMUM	26	1683	67.0	113.5	115.0	0.0
MAXIMUM	35	1747	86.0	115.0	118.0	4.5
AVERAGE	31	1715	76.5	114.3	116.5	2.3
STD DEV	4.5	32.0	9.5	0.8	1.5	2.3
VARIANCE	20	1024	90	1	2	5

EXPERIMENTAL GROUP - A (OTHER)
SAMPLE SIZE - 2

	AGE	HGHT	MASS	TRUNK INCLINATION 2 MIN	8 MIN	MOVEMEN
MINIMUM	25	1570	61.0	102.5	111.5	1.0
MAXIMUM	42	1734	70.0	116.0	115.0	9.0
AVERAGE	34	1652	65.5	109.3	113.3	5.0
STD DEV	8.5	82.0	4.5	6.8	1.8	4.0
VARIANCE	72	6724	20	46	3	16

EXPERIMENTAL GROUP - A (OVERALL)
SAMPLE SIZE - 47

	AGE	HGHT	MASS	HEAD INCLINATION 2 MIN	8 MIN	MOVEMEN
MINIMUM	21	1555	49.0	27.0	25.0	0.0
MAXIMUM	51	1938	100.0	60.0	62.0	26.0
AVERAGE	31	1706	69.2	43.0	43.6	6.4
STD DEV	7.2	92.6	11.8	9.1	9.4	4.9
VARIANCE	52	8578	139	82	88	24

EXPERIMENTAL GROUP - A (AUSTRALIAN
SAMPLE SIZE - 27

	AGE	HGHT	MASS	HEAD INCLINATION 2 MIN	8 MIN	MOVEMEN
MINIMUM	21	1568	60.0	27.0	25.0	0.0
MAXIMUM	51	1938	100.0	58.0	62.0	16.0
AVERAGE	29	1742	73.2	42.7	44.0	6.0
STD DEV	7.0	94.0	11.2	8.8	10.2	3.7
VARIANCE	49	8830	125	77	103	13

EXPERIMENTAL GROUP - A (ASIAN)
SAMPLE SIZE - 16

	AGE	HGHT	MASS	HEAD INCLINATION 2 MIN	8 MIN	MOVEMEN
MINIMUM	23	1555	49	27.0	27.0	0.0
MAXIMUM	50	1750	86	60.0	57.0	26.0
AVERAGE	33	1651	62	42.3	42.6	7.2
STD DEV	7.0	60.7	9.9	10.2	8.8	6.5
VARIANCE	49	3689	99	103	77	42

EXPERIMENTAL GROUP - A (EUROPEAN)
SAMPLE SIZE - 2

	AGE	HGHT	MASS	HEAD INCLINATION 2 MIN	8 MIN	MOVEMEN
MINIMUM	26	1683	67.0	48.0	39.0	4.0
MAXIMUM	35	1747	86.0	52.0	52.0	13.0
AVERAGE	31	1715	76.5	50.0	45.5	8.5
STD DEV	4.5	32.0	9.5	2.0	6.5	4.5
VARIANCE	20	1024	90	4	42	20

EXPERIMENTAL GROUP - A (OTHER)
SAMPLE SIZE - 2

	AGE	HGHT	MASS	HEAD INCLINATION 2 MIN	8 MIN	MOVEMEN
MINIMUM	25	1570	61.0	45.5	44.0	1.0
MAXIMUM	42	1734	70.0	47.0	44.5	3.0
AVERAGE	34	1652	65.5	46.3	44.3	2.0
STD DEV	8.5	82.0	4.5	0.8	0.3	1.0
VARIANCE	72	6724	20	1	0	1

EXPERIMENTAL GROUP - A (OVERALL)
SAMPLE SIZE - 47

	AGE	HGHT	MASS	ARM FLEXION 2 MIN	8 MIN	MOVEMEN
MINIMUM	21	1555	49.0	91.0	92.0	0.0
MAXIMUM	51	1938	100.0	132.0	132.0	22.0
AVERAGE	31	1706	69.2	105.3	106.6	4.8
STD DEV	7.2	92.6	11.8	7.8	8.3	4.1
VARIANCE	52	8578	139	62	68	17

EXPERIMENTAL GROUP - A (AUSTRALIAN
SAMPLE SIZE - 27

	AGE	HGHT	MASS	ARM FLEXION 2 MIN	8 MIN	MOVEMEN
MINIMUM	21	1568	60.0	91.0	92.0	0.0
MAXIMUM	51	1938	100.0	115.5	121.5	10.0
AVERAGE	29	1742	73.2	104.5	105.9	3.8
STD DEV	7.0	94.0	11.2	7.0	7.3	2.8
VARIANCE	49	8830	125	49	54	8

EXPERIMENTAL GROUP - A (ASIAN)
SAMPLE SIZE - 16

	AGE	HGHT	MASS	ARM FLEXION 2 MIN	8 MIN	MOVEMEN
MINIMUM	23	1555	49	95.0	95.0	0.0
MAXIMUM	50	1750	86	116.5	132.0	22.0
AVERAGE	33	1651	62	104.6	107.4	6.7
STD DEV	7.0	60.7	9.9	5.1	8.7	5.3
VARIANCE	49	3689	99	26	75	28

EXPERIMENTAL GROUP - A (EUROPEAN)
SAMPLE SIZE - 2

	AGE	HGHT	MASS	ARM FLEXION 2 MIN	8 MIN	MOVEMEN
MINIMUM	26	1683	67.0	95.5	93.5	2.0
MAXIMUM	35	1747	86.0	132.0	122.0	10.0
AVERAGE	31	1715	76.5	113.8	107.8	6.0
STD DEV	4.5	32.0	9.5	18.3	14.3	4.0
VARIANCE	20	1024	90	333	203	16

EXPERIMENTAL GROUP - A (OTHER)
SAMPLE SIZE - 2

	AGE	HGHT	MASS	ARM FLEXION 2 MIN	8 MIN	MOVEMEN
MINIMUM	25	1570	61.0	101.5	102.0	0.5
MAXIMUM	42	1734	70.0	123.0	117.0	6.0
AVERAGE	34	1652	65.5	112.3	109.5	3.3
STD DEV	8.5	82.0	4.5	10.7	7.5	2.7
VARIANCE	72	6724	20	116	56	8

EXPERIMENTAL GROUP - A (OVERALL)
SAMPLE SIZE - 47

				ARM ABDUCTION		
	AGE	HGHT	MASS	2 MIN	8 MIN	MOVEMEN
MINIMUM	21	1555	49.0	10.0	13.5	0.0
MAXIMUM	51	1938	100.0	37.0	36.5	11.5
AVERAGE	31	1706	69.2	23.6	24.0	2.9
STD DEV	7.2	92.6	11.8	6.8	6.2	2.9
VARIANCE	52	8578	139	46	38	8

EXPERIMENTAL GROUP - A (AUSTRALIAN
SAMPLE SIZE - 27

				ARM ABDUCTION		
	AGE	HGHT	MASS	2 MIN	8 MIN	MOVEMEN
MINIMUM	21	1568	60.0	15.0	17.5	0.5
MAXIMUM	51	1938	100.0	37.0	36.5	11.5
AVERAGE	29	1742	73.2	25.2	25.6	3.1
STD DEV	7.0	94.0	11.2	6.0	5.5	3.0
VARIANCE	49	8830	125	36	31	9

EXPERIMENTAL GROUP - A (ASIAN)
SAMPLE SIZE - 16

				ARM ABDUCTION		
	AGE	HGHT	MASS	2 MIN	8 MIN	MOVEMEN
MINIMUM	23	1555	49	13.5	14.0	0.0
MAXIMUM	50	1750	86	36.5	36.0	9.0
AVERAGE	33	1651	62	22.0	22.7	2.6
STD DEV	7.0	60.7	9.9	7.4	6.4	2.9
VARIANCE	49	3689	99	55	41	8

EXPERIMENTAL GROUP - A (EUROPEAN)
SAMPLE SIZE - 2

				ARM ABDUCTION		
	AGE	HGHT	MASS	2 MIN	8 MIN	MOVEMEN
MINIMUM	26	1683	67.0	22.0	20.0	0.0
MAXIMUM	35	1747	86.0	25.0	25.0	2.0
AVERAGE	31	1715	76.5	23.5	22.5	1.0
STD DEV	4.5	32.0	9.5	1.5	2.5	1.0
VARIANCE	20	1024	90	2	6	1

EXPERIMENTAL GROUP - A (OTHER)
SAMPLE SIZE - 2

				ARM ABDUCTION		
	AGE	HGHT	MASS	2 MIN	8 MIN	MOVEMEN
MINIMUM	25	1570	61.0	10.0	13.5	3.5
MAXIMUM	42	1734	70.0	20.5	15.5	5.0
AVERAGE	34	1652	65.5	15.3	14.5	4.3
STD DEV	8.5	82.0	4.5	5.2	1.0	0.8
VARIANCE	72	6724	20	28	1	1

EXPERIMENTAL GROUP - A (OVERALL)
SAMPLE SIZE - 47

	AGE	HGHT	MASS	ELBOW ANGLE 2 MIN	8 MIN	MOVEMEN
MINIMUM	21	1555	49.0	73.0	72.5	0.0
MAXIMUM	51	1938	100.0	111.0	110.0	12.0
AVERAGE	31	1706	69.2	90.0	90.6	3.8
STD DEV	7.2	92.6	11.8	9.1	8.6	2.9
VARIANCE	52	8578	139	82	74	8

EXPERIMENTAL GROUP - A (AUSTRALIAN
SAMPLE SIZE - 27

	AGE	HGHT	MASS	ELBOW ANGLE 2 MIN	8 MIN	MOVEMEN
MINIMUM	21	1568	60.0	75.5	72.5	0.0
MAXIMUM	51	1938	100.0	105.5	106.0	8.0
AVERAGE	29	1742	73.2	89.2	89.0	2.9
STD DEV	7.0	94.0	11.2	7.9	8.5	2.0
VARIANCE	49	8830	125	63	72	4

EXPERIMENTAL GROUP - A (ASIAN)
SAMPLE SIZE - 16

	AGE	HGHT	MASS	ELBOW ANGLE 2 MIN	8 MIN	MOVEMEN
MINIMUM	23	1555	49	73.0	80.0	0.0
MAXIMUM	50	1750	86	111.0	106.5	12.0
AVERAGE	33	1651	62	90.1	92.0	4.9
STD DEV	7.0	60.7	9.9	10.1	7.7	3.7
VARIANCE	49	3689	99	102	60	14

EXPERIMENTAL GROUP - A (EUROPEAN)
SAMPLE SIZE - 2

	AGE	HGHT	MASS	ELBOW ANGLE 2 MIN	8 MIN	MOVEMEN
MINIMUM	26	1683	67.0	91.0	86.5	4.5
MAXIMUM	35	1747	86.0	103.5	98.0	5.5
AVERAGE	31	1715	76.5	97.3	92.3	5.0
STD DEV	4.5	32.0	9.5	6.3	5.8	0.5
VARIANCE	20	1024	90	39	33	0

EXPERIMENTAL GROUP - A (OTHER)
SAMPLE SIZE - 2

	AGE	HGHT	MASS	ELBOW ANGLE 2 MIN	8 MIN	MOVEMEN
MINIMUM	25	1570	61.0	82.0	89.0	3.5
MAXIMUM	42	1734	70.0	106.5	110.0	7.0
AVERAGE	34	1652	65.5	94.3	99.5	5.3
STD DEV	8.5	82.0	4.5	12.3	10.5	1.8
VARIANCE	72	6724	20	150	110	3

EXPERIMENTAL GROUP - A (OVERALL)
SAMPLE SIZE - 47

	AGE	HGHT	MASS	LEFT ULNAR ABDUCTION 2 MIN	8 MIN	MOVEMEN
MINIMUM	21	1555	49.0	0.0	0.0	0.0
MAXIMUM	51	1938	100.0	23.0	16.5	12.0
AVERAGE	31	1706	69.2	5.1	5.1	2.3
STD DEV	7.2	92.6	11.8	5.0	4.2	2.6
VARIANCE	52	8578	139	25	17	7

EXPERIMENTAL GROUP - A (AUSTRALIAN
SAMPLE SIZE - 27

	AGE	HGHT	MASS	LEFT ULNAR ABDUCTION 2 MIN	8 MIN	MOVEMEN
MINIMUM	21	1568	60.0	0.0	0.0	0.0
MAXIMUM	51	1938	100.0	23.0	16.5	10.5
AVERAGE	29	1742	73.2	5.6	5.4	2.2
STD DEV	7.0	94.0	11.2	5.0	3.9	2.4
VARIANCE	49	8830	125	25	15	6

EXPERIMENTAL GROUP - A (ASIAN)
SAMPLE SIZE - 16

	AGE	HGHT	MASS	LEFT ULNAR ABDUCTION 2 MIN	8 MIN	MOVEMEN
MINIMUM	23	1555	49	0.0	0.0	0.0
MAXIMUM	50	1750	86	9.0	13.0	5.5
AVERAGE	33	1651	62	3.9	4.8	1.8
STD DEV	7.0	60.7	9.9	3.8	4.5	1.9
VARIANCE	49	3689	99	15	21	4

EXPERIMENTAL GROUP - A (EUROPEAN)
SAMPLE SIZE - 2

	AGE	HGHT	MASS	LEFT ULNAR ABDUCTION 2 MIN	8 MIN	MOVEMEN
MINIMUM	26	1683	67.0	2.0	0.0	2.0
MAXIMUM	35	1747	86.0	19.5	7.5	12.0
AVERAGE	31	1715	76.5	10.8	3.8	7.0
STD DEV	4.5	32.0	9.5	8.8	3.8	5.0
VARIANCE	20	1024	90	77	14	25

EXPERIMENTAL GROUP - A (OTHER)
SAMPLE SIZE - 2

	AGE	HGHT	MASS	LEFT ULNAR ABDUCTION 2 MIN	8 MIN	MOVEMEN
MINIMUM	25	1570	61.0	0.0	0.5	0.5
MAXIMUM	42	1734	70.0	4.0	10.0	6.0
AVERAGE	34	1652	65.5	2.0	5.3	3.3
STD DEV	8.5	82.0	4.5	2.0	4.8	2.7
VARIANCE	72	6724	20	4	23	8

STATISTICAL SUMMARY BY NATIONALITY - B

(TABLES)

EXPERIMENTAL GROUP - B (OVERALL)
SAMPLE SIZE - 47

	AGE	HGHT	MASS	EYE/FLOOR DISTANCE 2 MIN	8 MIN	MOVEMEN
MINIMUM	20	1441	45.0	1005	1010	0
MAXIMUM	61	1811	105.0	1680	1640	100
AVERAGE	29	1637	62.8	1213	1219	26
STD DEV	8.1	82.8	12.4	159.5	165.8	27.0
VARIANCE	65	6864	153	25433	27492	728

EXPERIMENTAL GROUP - B (AUSTRALIAN
SAMPLE SIZE - 31

	AGE	HGHT	MASS	EYE/FLOOR DISTANCE 2 MIN	8 MIN	MOVEMEN
MINIMUM	20	1479	45.5	1005	1010	0
MAXIMUM	61	1778	105.0	1558	1550	100
AVERAGE	30	1644	64.4	1197	1202	23
STD DEV	9.1	71.3	11.6	131.2	138.0	23.8
VARIANCE	83	5079	135	17218	19037	565

EXPERIMENTAL GROUP - B (ASIAN)
SAMPLE SIZE - 3

	AGE	HGHT	MASS	EYE/FLOOR DISTANCE 2 MIN	8 MIN	MOVEMEN
MINIMUM	25	1441	45.0	1060	1055	5
MAXIMUM	36	1607	52.0	1115	1138	23
AVERAGE	29	1524	47.3	1092	1096	11
STD DEV	5.2	67.8	3.3	23.2	33.9	8.3
VARIANCE	27	4593	11	539	1150	68

EXPERIMENTAL GROUP - B (EUROPEAN)
SAMPLE SIZE - 8

	AGE	HGHT	MASS	EYE/FLOOR DISTANCE 2 MIN	8 MIN	MOVEMEN
MINIMUM	20	1568	47.7	1110	1110	0
MAXIMUM	28	1734	92.0	1680	1640	100
AVERAGE	24	1635	64.9	1275	1271	36
STD DEV	2.7	56.1	14.6	203.5	200.9	35.3
VARIANCE	8	3145	212	41410	40341	1248

EXPERIMENTAL GROUP - B (OTHER)
SAMPLE SIZE - 5

	AGE	HGHT	MASS	EYE/FLOOR DISTANCE 2 MIN	8 MIN	MOVEMEN
MINIMUM	22	1479	50.0	1092	1092	0
MAXIMUM	36	1811	73.0	1540	1600	73
AVERAGE	27	1668	58.7	1283	1317	35
STD DEV	4.7	127.8	8.3	210.6	224.5	29.7
VARIANCE	22	16327	69	44358	50418	882

EXPERIMENTAL GROUP - B (OVERALL)
SAMPLE SIZE - 47

	AGE	HGHT	MASS	ACROMION/KEYBOARD DISTANCE 2 MIN	8 MIN	MOVEMEN
MINIMUM	20	1441	45.0	201	183	0
MAXIMUM	61	1811	105.0	330	332	50
AVERAGE	29	1637	62.8	262	261	12
STD DEV	8.1	82.8	12.4	29.2	28.8	9.9
VARIANCE	65	6864	153	853	828	99

EXPERIMENTAL GROUP - B (AUSTRALIAN
SAMPLE SIZE - 31

	AGE	HGHT	MASS	ACROMION/KEYBOARD DISTANCE 2 MIN	8 MIN	MOVEMEN
MINIMUM	20	1479	45.5	208	215	0
MAXIMUM	61	1778	105.0	311	310	50
AVERAGE	30	1644	64.4	263	263	14
STD DEV	9.1	71.3	11.6	29.1	25.5	10.9
VARIANCE	83	5079	135	846	652	120

EXPERIMENTAL GROUP - B (ASIAN)
SAMPLE SIZE - 3

	AGE	HGHT	MASS	ACROMION/KEYBOARD DISTANCE 2 MIN	8 MIN	MOVEMEN
MINIMUM	25	1441	45.0	231	229	6
MAXIMUM	36	1607	52.0	245	267	22
AVERAGE	29	1524	47.3	237	245	12
STD DEV	5.2	67.8	3.3	5.9	16.0	6.9
VARIANCE	27	4593	11	35	255	48

EXPERIMENTAL GROUP - B (EUROPEAN)
SAMPLE SIZE - 8

	AGE	HGHT	MASS	ACROMION/KEYBOARD DISTANCE 2 MIN	8 MIN	MOVEMEN
MINIMUM	20	1568	47.7	239	233	1
MAXIMUM	28	1734	92.0	330	332	10
AVERAGE	24	1635	64.9	271	269	5
STD DEV	2.7	56.1	14.6	26.1	29.1	2.8
VARIANCE	8	3145	212	681	848	8

EXPERIMENTAL GROUP - B (OTHER)
SAMPLE SIZE - 5

	AGE	HGHT	MASS	ACROMION/KEYBOARD DISTANCE 2 MIN	8 MIN	MOVEMEN
MINIMUM	22	1479	50.0	201	183	2
MAXIMUM	36	1811	73.0	300	310	18
AVERAGE	27	1668	58.7	254	249	10
STD DEV	4.7	127.8	8.3	33.0	42.6	6.5
VARIANCE	22	16327	69	1091	1811	43

EXPERIMENTAL GROUP - B (OVERALL)
SAMPLE SIZE - 47

	AGE	HGHT	MASS	EYE/COPY DISTANCE 2 MIN	8 MIN	MOVEMEN
MINIMUM	20	1441	45.0	478	488	0
MAXIMUM	61	1811	105.0	850	876	93
AVERAGE	29	1637	62.8	700	707	26
STD DEV	8.1	82.8	12.4	77.4	87.0	21.3
VARIANCE	65	6864	153	5992	7568	455

EXPERIMENTAL GROUP - B (AUSTRALIAN
SAMPLE SIZE - 31

	AGE	HGHT	MASS	EYE/COPY DISTANCE 2 MIN	8 MIN	MOVEMEN
MINIMUM	20	1479	45.5	478	488	0
MAXIMUM	61	1778	105.0	850	876	93
AVERAGE	30	1644	64.4	691	697	28
STD DEV	9.1	71.3	11.6	79.1	90.9	24.6
VARIANCE	83	5079	135	6260	8268	603

EXPERIMENTAL GROUP - B (ASIAN)
SAMPLE SIZE - 3

	AGE	HGHT	MASS	EYE/COPY DISTANCE 2 MIN	8 MIN	MOVEMEN
MINIMUM	25	1441	45.0	723	708	12
MAXIMUM	36	1607	52.0	788	786	18
AVERAGE	29	1524	47.3	760	757	15
STD DEV	5.2	67.8	3.3	27.2	34.7	2.4
VARIANCE	27	4593	11	739	1201	6

EXPERIMENTAL GROUP - B (EUROPEAN)
SAMPLE SIZE - 8

	AGE	HGHT	MASS	EYE/COPY DISTANCE 2 MIN	8 MIN	MOVEMEN
MINIMUM	20	1568	47.7	568	586	9
MAXIMUM	28	1734	92.0	823	845	50
AVERAGE	24	1635	64.9	686	691	20
STD DEV	2.7	56.1	14.6	81.1	82.7	11.9
VARIANCE	8	3145	212	6576	6838	141

EXPERIMENTAL GROUP - B (OTHER)
SAMPLE SIZE - 5

	AGE	HGHT	MASS	EYE/COPY DISTANCE 2 MIN	8 MIN	MOVEMEN
MINIMUM	22	1479	50.0	692	712	5
MAXIMUM	36	1811	73.0	814	843	40
AVERAGE	27	1668	58.7	745	769	26
STD DEV	4.7	127.8	8.3	40.1	43.0	12.7
VARIANCE	22	16327	69	1612	1849	161

EXPERIMENTAL GROUP - B (OVERALL)
SAMPLE SIZE - 47

				TRUNK INCLINATION		
	AGE	HGHT	MASS	2 MIN	8 MIN	MOVEMEN
MINIMUM	20	1441	45.0	74	75.0	0.0
MAXIMUM	61	1811	105.0	125	124.5	22.5
AVERAGE	29	1637	62.8	107	107.6	6.9
STD DEV	8.1	82.8	12.4	10.7	11.0	5.4
VARIANCE	65	6864	153	114	121	29

EXPERIMENTAL GROUP - B (AUSTRALIAN
SAMPLE SIZE - 31

				TRUNK INCLINATION		
	AGE	HGHT	MASS	2 MIN	8 MIN	MOVEMEN
MINIMUM	20	1479	45.5	83.5	83.5	0.0
MAXIMUM	61	1778	105.0	125.0	124.5	22.5
AVERAGE	30	1644	64.4	108.5	109.0	6.7
STD DEV	9.1	71.3	11.6	9.6	9.3	5.2
VARIANCE	83	5079	135	91	86	27

EXPERIMENTAL GROUP - B (ASIAN)
SAMPLE SIZE - 3

				TRUNK INCLINATION		
	AGE	HGHT	MASS	2 MIN	8 MIN	MOVEMEN
MINIMUM	25	1441	45.0	104.0	87.5	4.5
MAXIMUM	36	1607	52.0	105.5	120.0	17.0
AVERAGE	29	1524	47.3	104.7	105.3	12.0
STD DEV	5.2	67.8	3.3	0.6	13.5	5.4
VARIANCE	27	4593	11	0	181	29

EXPERIMENTAL GROUP - B (EUROPEAN)
SAMPLE SIZE - 8

				TRUNK INCLINATION		
	AGE	HGHT	MASS	2 MIN	8 MIN	MOVEMEN
MINIMUM	20	1568	47.7	74.0	75.0	1.0
MAXIMUM	28	1734	92.0	121.0	121.5	18.5
AVERAGE	24	1635	64.9	103.1	105.9	7.2
STD DEV	2.7	56.1	14.6	14.7	13.9	5.8
VARIANCE	8	3145	212	215	194	33

EXPERIMENTAL GROUP - B (OTHER)
SAMPLE SIZE - 5

				TRUNK INCLINATION		
	AGE	HGHT	MASS	2 MIN	8 MIN	MOVEMEN
MINIMUM	22	1479	50.0	85.5	81.0	1.0
MAXIMUM	36	1811	73.0	114.0	115.0	12.5
AVERAGE	27	1668	58.7	106.9	103.0	4.9
STD DEV	4.7	127.8	8.3	10.8	11.9	4.0
VARIANCE	22	16327	69	116	142	16

EXPERIMENTAL GROUP - B (OVERALL)
SAMPLE SIZE - 47

	AGE	HGHT	MASS	HEAD INCLINATION 2 MIN	8 MIN	MOVEMEN
MINIMUM	20	1441	45.0	20.0	14.0	0.0
MAXIMUM	61	1811	105.0	51.0	57.0	21.5
AVERAGE	29	1637	62.8	32.2	30.3	6.2
STD DEV	8.1	82.8	12.4	6.2	9.4	5.1
VARIANCE	65	6864	153	38	89	26

EXPERIMENTAL GROUP - B (AUSTRALIAN
SAMPLE SIZE - 31

	AGE	HGHT	MASS	HEAD INCLINATION 2 MIN	8 MIN	MOVEMEN
MINIMUM	20	1479	45.5	20.0	14.0	0.0
MAXIMUM	61	1778	105.0	51.0	53.0	19.5
AVERAGE	30	1644	64.4	32.3	29.9	6.1
STD DEV	9.1	71.3	11.6	6.6	9.3	5.0
VARIANCE	83	5079	135	44	86	25

EXPERIMENTAL GROUP - B (ASIAN)
SAMPLE SIZE - 3

	AGE	HGHT	MASS	HEAD INCLINATION 2 MIN	8 MIN	MOVEMEN
MINIMUM	25	1441	45.0	25.5	24.5	1.0
MAXIMUM	36	1607	52.0	35.5	57.0	21.5
AVERAGE	29	1524	47.3	30.3	36.3	8.3
STD DEV	5.2	67.8	3.3	4.1	14.7	9.3
VARIANCE	27	4593	11	17	215	87

EXPERIMENTAL GROUP - B (EUROPEAN)
SAMPLE SIZE - 8

	AGE	HGHT	MASS	HEAD INCLINATION 2 MIN	8 MIN	MOVEMEN
MINIMUM	20	1568	47.7	21.0	14.0	3.0
MAXIMUM	28	1734	92.0	35.0	39.5	18.0
AVERAGE	24	1635	64.9	30.7	28.8	6.1
STD DEV	2.7	56.1	14.6	4.7	8.3	4.7
VARIANCE	8	3145	212	22	69	22

EXPERIMENTAL GROUP - B (OTHER)
SAMPLE SIZE - 5

	AGE	HGHT	MASS	HEAD INCLINATION 2 MIN	8 MIN	MOVEMEN
MINIMUM	22	1479	50.0	30.0	25.5	3.0
MAXIMUM	36	1811	73.0	44.0	39.0	7.5
AVERAGE	27	1668	58.7	34.8	32.2	5.4
STD DEV	4.7	127.8	8.3	5.0	5.4	1.7
VARIANCE	22	16327	69	25	29	3

EXPERIMENTAL GROUP - B (OVERALL)
SAMPLE SIZE - 47

	AGE	HGHT	MASS	ARM FLEXION 2 MIN	8 MIN	MOVEMEN
MINIMUM	20	1441	45.0	88.5	91.5	0.0
MAXIMUM	61	1811	105.0	123.0	123.5	27.5
AVERAGE	29	1637	62.8	103.4	103.8	4.4
STD DEV	8.1	82.8	12.4	7.8	7.4	5.1
VARIANCE	65	6864	153	61	54	26

EXPERIMENTAL GROUP - B (AUSTRALIAN
SAMPLE SIZE - 31

	AGE	HGHT	MASS	ARM FLEXION 2 MIN	8 MIN	MOVEMEN
MINIMUM	20	1479	45.5	88.5	91.5	0.0
MAXIMUM	61	1778	105.0	122.5	120.5	27.5
AVERAGE	30	1644	64.4	102.9	102.5	4.7
STD DEV	9.1	71.3	11.6	7.9	7.5	5.7
VARIANCE	83	5079	135	63	57	32

EXPERIMENTAL GROUP - B (ASIAN)
SAMPLE SIZE - 3

	AGE	HGHT	MASS	ARM FLEXION 2 MIN	8 MIN	MOVEMEN
MINIMUM	25	1441	45.0	106.5	103.0	3.5
MAXIMUM	36	1607	52.0	112.5	106.5	7.0
AVERAGE	29	1524	47.3	110.0	104.5	5.5
STD DEV	5.2	67.8	3.3	2.5	1.5	1.5
VARIANCE	27	4593	11	7	2	2

EXPERIMENTAL GROUP - B (EUROPEAN)
SAMPLE SIZE - 8

	AGE	HGHT	MASS	ARM FLEXION 2 MIN	8 MIN	MOVEMEN
MINIMUM	20	1568	47.7	92.0	96.5	0.0
MAXIMUM	28	1734	92.0	123.0	123.5	6.0
AVERAGE	24	1635	64.9	106.1	108.3	2.4
STD DEV	2.7	56.1	14.6	8.2	7.3	2.1
VARIANCE	8	3145	212	67	53	4

EXPERIMENTAL GROUP - B (OTHER)
SAMPLE SIZE - 5

	AGE	HGHT	MASS	ARM FLEXION 2 MIN	8 MIN	MOVEMEN
MINIMUM	22	1479	50.0	95.5	96.0	0.5
MAXIMUM	36	1811	73.0	100.5	111.5	14.0
AVERAGE	27	1668	58.7	98.2	103.8	5.6
STD DEV	4.7	127.8	8.3	1.7	5.3	5.0
VARIANCE	22	16327	69	3	28	25

EXPERIMENTAL GROUP - B (OVERALL)
SAMPLE SIZE - 47

	AGE	HGHT	MASS	ARM ABDUCTION 2 MIN	8 MIN	MOVEMEN
MINIMUM	20	1441	45.0	16.5	13.0	0.0
MAXIMUM	61	1811	105.0	40.5	44.0	10.5
AVERAGE	29	1637	62.8	24.9	25.0	4.1
STD DEV	8.1	82.8	12.4	5.8	6.1	2.9
VARIANCE	65	6864	153	34	37	9

EXPERIMENTAL GROUP - B (AUSTRALIAN
SAMPLE SIZE - 31

	AGE	HGHT	MASS	ARM ABDUCTION 2 MIN	8 MIN	MOVEMEN
MINIMUM	20	1479	45.5	16.5	13.0	0.0
MAXIMUM	61	1778	105.0	39.0	37.5	10.5
AVERAGE	30	1644	64.4	23.8	24.7	3.8
STD DEV	9.1	71.3	11.6	4.7	5.1	3.1
VARIANCE	83	5079	135	22	26	10

EXPERIMENTAL GROUP - B (ASIAN)
SAMPLE SIZE - 3

	AGE	HGHT	MASS	ARM ABDUCTION 2 MIN	8 MIN	MOVEMEN
MINIMUM	25	1441	45.0	26.5	26.0	0.5
MAXIMUM	36	1607	52.0	40.5	31.5	9.0
AVERAGE	29	1524	47.3	33.8	28.8	5.0
STD DEV	5.2	67.8	3.3	5.7	2.2	3.5
VARIANCE	27	4593	11	33	5	12

EXPERIMENTAL GROUP - B (EUROPEAN)
SAMPLE SIZE - 8

	AGE	HGHT	MASS	ARM ABDUCTION 2 MIN	8 MIN	MOVEMEN
MINIMUM	20	1568	47.7	16.5	13.0	0.5
MAXIMUM	28	1734	92.0	37.5	44.0	7.5
AVERAGE	24	1635	64.9	26.0	26.6	4.2
STD DEV	2.7	56.1	14.6	7.4	9.7	2.3
VARIANCE	8	3145	212	55	94	5

EXPERIMENTAL GROUP - B (OTHER)
SAMPLE SIZE - 5

	AGE	HGHT	MASS	ARM ABDUCTION 2 MIN	8 MIN	MOVEMEN
MINIMUM	22	1479	50.0	18.5	16.5	2.0
MAXIMUM	36	1811	73.0	29.5	27.5	7.5
AVERAGE	27	1668	58.7	24.7	22.4	4.9
STD DEV	4.7	127.8	8.3	4.2	3.9	1.9
VARIANCE	22	16327	69	18	15	4

EXPERIMENTAL GROUP - B (OVERALL)
SAMPLE SIZE - 47

	AGE	HGHT	MASS	ELBOW ANGLE 2 MIN	8 MIN	MOVEMEN
MINIMUM	20	1441	45.0	75.0	79.5	0.0
MAXIMUM	61	1811	105.0	120.5	121.5	32.0
AVERAGE	29	1637	62.8	97.1	97.0	7.1
STD DEV	8.1	82.8	12.4	10.7	10.8	7.2
VARIANCE	65	6864	153	115	117	52

EXPERIMENTAL GROUP - B (AUSTRALIAN
SAMPLE SIZE - 31

	AGE	HGHT	MASS	ELBOW ANGLE 2 MIN	8 MIN	MOVEMEN
MINIMUM	20	1479	45.5	78.5	79.5	0.0
MAXIMUM	61	1778	105.0	115.0	116.0	27.5
AVERAGE	30	1644	64.4	97.1	96.2	5.7
STD DEV	9.1	71.3	11.6	9.6	9.9	6.3
VARIANCE	83	5079	135	92	99	39

EXPERIMENTAL GROUP - B (ASIAN)
SAMPLE SIZE - 3

	AGE	HGHT	MASS	ELBOW ANGLE 2 MIN	8 MIN	MOVEMEN
MINIMUM	25	1441	45.0	109.5	81.5	0.0
MAXIMUM	36	1607	52.0	120.5	120.5	32.0
AVERAGE	29	1524	47.3	114.5	96.2	18.3
STD DEV	5.2	67.8	3.3	4.5	17.3	13.5
VARIANCE	27	4593	11	21	300	182

EXPERIMENTAL GROUP - B (EUROPEAN)
SAMPLE SIZE - 8

	AGE	HGHT	MASS	ELBOW ANGLE 2 MIN	8 MIN	MOVEMEN
MINIMUM	20	1568	47.7	77.5	84.0	1.5
MAXIMUM	28	1734	92.0	116.5	121.5	12.5
AVERAGE	24	1635	64.9	95.2	100.0	6.7
STD DEV	2.7	56.1	14.6	10.9	11.7	2.9
VARIANCE	8	3145	212	119	137	9

EXPERIMENTAL GROUP - B (OTHER)
SAMPLE SIZE - 5

	AGE	HGHT	MASS	ELBOW ANGLE 2 MIN	8 MIN	MOVEMEN
MINIMUM	22	1479	50.0	75.0	83.5	2.0
MAXIMUM	36	1811	73.0	98.5	108.0	19.0
AVERAGE	27	1668	58.7	89.5	97.9	9.2
STD DEV	4.7	127.8	8.3	7.9	8.1	5.5
VARIANCE	22	16327	69	62	66	30

EXPERIMENTAL GROUP - B (OVERALL)
SAMPLE SIZE - 47

	AGE	HGHT	MASS	LEFT ULNAR ABDUCTION 2 MIN	8 MIN	MOVEMEN
MINIMUM	20	1441	45.0	0.0	0.0	0.0
MAXIMUM	61	1811	105.0	32.0	23.5	12.5
AVERAGE	29	1637	62.8	10.4	11.1	3.3
STD DEV	8.1	82.8	12.4	5.6	5.4	2.8
VARIANCE	65	6864	153	31	29	8

EXPERIMENTAL GROUP - B (AUSTRALIAN
SAMPLE SIZE - 31

	AGE	HGHT	MASS	LEFT ULNAR ABDUCTION 2 MIN	8 MIN	MOVEMEN
MINIMUM	20	1479	45.5	0.0	2.5	0.0
MAXIMUM	61	1778	105.0	32.0	23.5	12.5
AVERAGE	30	1644	64.4	10.8	11.3	3.2
STD DEV	9.1	71.3	11.6	5.9	5.4	2.7
VARIANCE	83	5079	135	35	29	7

EXPERIMENTAL GROUP - B (ASIAN)
SAMPLE SIZE - 3

	AGE	HGHT	MASS	LEFT ULNAR ABDUCTION 2 MIN	8 MIN	MOVEMEN
MINIMUM	25	1441	45.0	0.0	0.0	0.0
MAXIMUM	36	1607	52.0	9.5	18.5	10.5
AVERAGE	29	1524	47.3	5.8	10.2	4.3
STD DEV	5.2	67.8	3.3	4.2	7.7	4.5
VARIANCE	27	4593	11	17	59	20

EXPERIMENTAL GROUP - B (EUROPEAN)
SAMPLE SIZE - 8

	AGE	HGHT	MASS	LEFT ULNAR ABDUCTION 2 MIN	8 MIN	MOVEMEN
MINIMUM	20	1568	47.7	5.5	7.0	0.5
MAXIMUM	28	1734	92.0	15.5	16.5	6.0
AVERAGE	24	1635	64.9	12.0	12.0	2.4
STD DEV	2.7	56.1	14.6	3.3	4.0	1.7
VARIANCE	8	3145	212	11	16	3

EXPERIMENTAL GROUP - B (OTHER)
SAMPLE SIZE - 5

	AGE	HGHT	MASS	LEFT ULNAR ABDUCTION 2 MIN	8 MIN	MOVEMEN
MINIMUM	22	1479	50.0	0.0	2.5	2.5
MAXIMUM	36	1811	73.0	12.5	18.0	9.5
AVERAGE	27	1668	58.7	7.8	9.3	4.5
STD DEV	4.7	127.8	8.3	4.8	5.1	2.8
VARIANCE	22	16327	69	23	26	8

STATISTICAL SUMMARY COMBINED

(TABLES)

EXPERIMENTAL GROUPS-A&B (COMBINED)
SAMPLE SIZE - 94

	AGE	HGHT	MASS	EYE/FLOOR DISTANCE 2 MIN	8 MIN	MOVEMEN
MINIMUM	20	1441	45.0	1005	1010	0
MAXIMUM	61	1938	105.0	1680	1640	100
AVERAGE	30	1672	66.0	1226	1230	18
STD DEV	7.8	94.4	12.5	115.4	118.8	22.7
VARIANCE	60	8912	157	13310	14125	517

EXPERIMENTAL GROUPS-A&B (COMBINED) SAMPLE SIZE - 94				ACROMION/KEYBOARD DISTANCE		
	AGE	HGHT	MASS	2 MIN	8 MIN	MOVEMEN
MINIMUM	20	1441	45.0	178	183	0
MAXIMUM	61	1938	105.0	330	332	50
AVERAGE	30	1672	66.0	253	253	11
STD DEV	7.8	94.4	12.5	33.2	31.6	9.2
VARIANCE	60	8912	157	1105	998	85

EXPERIMENTAL GROUPS-A&B (COMBINED)
SAMPLE SIZE - 94

	AGE	HGHT	MASS	EYE/COPY DISTANCE 2 MIN	8 MIN	MOVEMEN
MINIMUM	20	1441	45.0	478	488	0
MAXIMUM	61	1938	105.0	850	876	93
AVERAGE	30	1672	66.0	685	689	21
STD DEV	7.8	94.4	12.5	67.1	74.1	20.3
VARIANCE	60	8912	157	4503	5486	412

EXPERIMENTAL GROUPS-A&B (COMBINED)
SAMPLE SIZE - 94

	AGE	HGHT	MASS	TRUNK INCLINATION 2 MIN	8 MIN	MOVEMEN
MINIMUM	20	1441	45.0	74.0	75.0	0.0
MAXIMUM	61	1938	105.0	130.0	129.0	27.0
AVERAGE	30	1672	66.0	108.0	108.8	6.2
STD DEV	7.8	94.4	12.5	10.4	10.7	5.5
VARIANCE	60	8912	157	109	115	30

EXPERIMENTAL GROUPS-A&B (COMBINED)
SAMPLE SIZE - 94

				HEAD INCLINATION		
	AGE	HGHT	MASS	2 MIN	8 MIN	MOVEMEN
MINIMUM	20	1441	45.0	20.0	14.0	0.0
MAXIMUM	61	1938	105.0	60.0	62.0	26.0
AVERAGE	30	1672	66.0	37.6	37.0	6.3
STD DEV	7.8	94.4	12.5	9.5	11.5	5.0
VARIANCE	60	8912	157	90	132	25

EXPERIMENTAL GROUPS-A&B (COMBINED)
SAMPLE SIZE - 94

	AGE	HGHT	MASS	ARM FLEXION 2 MIN	ARM FLEXION 8 MIN	ARM FLEXION MOVEMEN
MINIMUM	20	1441	45.0	88.5	91.5	0.0
MAXIMUM	61	1938	105.0	132.0	132.0	27.5
AVERAGE	30	1672	66.0	104.3	105.2	4.6
STD DEV	7.8	94.4	12.5	7.9	8.0	4.6
VARIANCE	60	8912	157	62	63	21

EXPERIMENTAL GROUPS-A&B (COMBINED)
SAMPLE SIZE - 94

	AGE	HGHT	MASS	ARM ABDUCTION 2 MIN	8 MIN	MOVEMEN
MINIMUM	20	1441	45.0	10.0	13.0	0.0
MAXIMUM	61	1938	105.0	40.5	44.0	11.5
AVERAGE	30	1672	66.0	24.2	24.5	3.5
STD DEV	7.8	94.4	12.5	6.3	6.2	3.0
VARIANCE	60	8912	157	40	38	9

EXPERIMENTAL GROUPS-A&B (COMBINED)
SAMPLE SIZE - 94

	AGE	HGHT	MASS	ELBOW ANGLE 2 MIN	8 MIN	MOVEMEN
MINIMUM	20	1441	45.0	73.0	72.5	0.0
MAXIMUM	61	1938	105.0	120.5	121.5	32.0
AVERAGE	30	1672	66.0	93.6	93.8	5.4
STD DEV	7.8	94.4	12.5	10.5	10.3	5.7
VARIANCE	60	8912	157	111	105	33

EXPERIMENTAL GROUPS-A&B (COMBINED)
SAMPLE SIZE - 94

	AGE	HGHT	MASS	LEFT ULNAR ABDUCTION 2 MIN	8 MIN	MOVEMEN
MINIMUM	20	1441	45.0	0.0	0.0	0.0
MAXIMUM	61	1938	105.0	32.0	23.5	12.5
AVERAGE	30	1672	66.0	7.7	8.1	2.8
STD DEV	7.8	94.4	12.5	5.9	5.7	2.8
VARIANCE	60	8912	157	35	32	8