2021

Methods of the Michigan State University Motor Performance Study

Karin A. Pfeiffer
Michigan State University

Larissa True
New Mexico State University

Eric Martin
Boise State University

Shannon R. Siegel
University of San Francisco

Crystal F. Branta
Michigan State University

See next page for additional authors

This is an Accepted Manuscript of an article published by Taylor & Francis in *Measurement in Physical Education and Exercise Science* on 2021, available online: https://doi.org/10.1080/1091367X.2020.1774888

Methods of the Michigan State University Motor Performance Study

Karin A. Pfeiffer*
Michigan State University
kap@msu.edu

Larissa True
New Mexico State University

Eric Martin
Boise State University

Shannon R. Siegel
University of San Francisco

Crystal F. Branta
Michigan State University

John Haubenstricker
Michigan State University

Vern Seefeldt
Michigan State University

Abstract

The Michigan State University Motor Performance Study (MPS) was initiated in 1967 and lasted 32 years. Three central components existed: 1) Educational component, in which students experienced applied work with youth; 2) Instructional component, whereby enrolled youth received sport-specific skill instruction; and 3) Research component. The primary goals of the research component of the MPS were to examine: 1) the changes over time that occur in the physical growth, biological maturity, and motor skill acquisition of children and youth; 2) the processes involved in the attainment of basic and complex motor skills; and 3) the influence of changes in the learners' environment on their rates of motor skill acquisition. Several growth and maturation, motor competence, and physical fitness variables were collected, and a follow-up study examined participants' adult physical activity, sport participation, and health outcomes. This manuscript describes methods used in the research component of the MPS and the follow-up.

Keywords: protocol, motor competence, fundamental motor skills, children, adolescents

The study of growth, maturation, and development (in particular, motor competence) offers insight into physical performance and physical activity, especially in youth (Malina, Bouchard, & Bar-Or, 2004), and physical inactivity in turn relates to future disease status (Lee et al., 2012). As such, many researchers have been interested in growth, maturation, and development and their associations with physical variables across time. Although some growth and motor competence studies occurred prior to 1900 (Tanner, 1981), many studies in Europe and the United States occurred during the 1900s (Malina et al., 2004). Growth and motor competence studies are difficult endeavors, as they require multiple assessments over time, and the longitudinal nature of the work elicits challenges such as participant drop-out, attrition, and measurement burden. One of those studies is the Michigan State University (MSU) Motor Performance Study (MPS).

The MSU MPS began in 1967 with an anticipated projection of 10 years, but instead lasted for a period of 32 years. Dr. Vern Seefeldt (Principal Investigator, PI) was primarily responsible for the inception of the MPS, which has been referred to as his "brainchild" (Haubenstricker & Feltz, 1999). In fact, Seefeldt's employment at MSU was partially contingent upon conducting pediatric research on the MSU campus. Throughout his career, Seefeldt produced seminal research studies and reports in the area of motor development and youth sport. In current motor development literature, Seefeldt is arguably most well-known for his "proficiency barrier" concept, whereby he proposed that children who are not exposed to a repertoire of fundamental motor skills before a critical period are highly susceptible to difficulty persisting in physically-demanding activities (Seefeldt, 1980). PI Seefeldt collaborated with Drs. John Haubenstricker and Crystal Branta, who also provided significant contributions to the MPS.

The initial premise of the MPS was to collect a longitudinal data set consisting of physical growth, biological maturity, and gross motor skill acquisition variables of children and youth. As the study evolved, there became three central components to the MPS: 1) An educational component, in which undergraduate students were provided the opportunity for applied work and experience with elementary-aged youth; 2) An instructional component, whereby youth enrolled in the program were exposed to sport-specific skill instruction under the direction of experts in the field; and 3) A research component. The primary goals of the research component were to examine: 1) the changes over time that occur in the physical growth, biological maturity, and motor skill acquisition of children and youth; 2) the processes involved in the attainment of basic and complex motor skills; and 3) the influence of changes in the learners' environment on their rates of motor skill acquisition (Haubenstricker & Feltz, 1999).

The primary purpose of this manuscript is to explain, in depth, the methods of the various measures (e.g., physical growth, biological maturity, motor competence, physical fitness, and the follow-up study) included in the research component of the MPS. A secondary purpose is to explain, briefly, the educational and instructional components of the MPS. In sum, this manuscript is intended to lay the groundwork for methods sections in subsequent studies that use data from the MPS.

Methods

Participants

Participation in the research component of the MPS was voluntary, and recruitment occurred via word of mouth and an initial newspaper story highlighting the study. Participants attended schools in 20 districts near the university and were healthy, free of overt disease, and had no major disabilities. Guardians of enrollees were tasked with committing to maintain their child's participation in the research study to the point of mature physical growth (i.e., roughly the age of 18). The MPS included measures of growth in children as early as 2.0 years (although a few with older siblings were assessed at 18 months), with the typical first age of assessment being 5.0 years. Participation numbers for the MPS varied annually as new participants were added and/or other participants "aged out" or moved away from the area. Participation totaled 591 in December of 1968 (the end of the first full year of the MPS), peaked at $n = 1487$ in 1975, and declined steadily until its conclusion in 1999 with 78 participants. Over the course of the MPS, data were obtained on over 1200 participants, with the number of intra-individual assessments ranging from 1 to 38 (Haubenstricker & Feltz, 1999).

In the mid- to late-1990s, a follow-up study was conducted. Participants were eligible to participate in the follow-up study if they participated in a minimum of eight consecutive data collection sessions throughout the duration of the MPS. Details of the follow-up appear later in this manuscript. At the study's initiation, an Institutional Review Board (IRB) did not exist. Once an IRB was created, approval for this study was sought and attained, and approval was obtained for the follow-up study.

Scope

The educational and instructional components of the MPS were, respectively, centered on providing MSU students with the opportunity to observe and teach children, and to help children learn and develop motor skills. The instructional component of the MPS was offered to children and adolescents 5.0 – 13.0 years of age. The activities that were taught by the MSU students and practiced by youth were developmentally- and age-appropriate as determined by Dr. Seefeldt and instructed by highly trained individuals, many of whom were graduate students. For example, children in kindergarten and first grade received the most broad instruction in terms of the skills they were taught (e.g., running, jumping, balancing, throwing, striking, swimming, dancing, and ice skating). Children in the second and third grades were exposed to similar skills, but in a more sport-specific context. Fourth and fifth graders were given instruction in complex skills, games, and gymnastic activities. The oldest youth in the cohort received strategy-based instruction on individual and team sports. The instructional component of the MPS was given in two 50-minute sessions on Saturday mornings during regular semesters. The number of sessions offered varied from 8 per quarterly term (1967-1992; e.g., 16 sessions per half year) to approximately 11 per semester when MSU converted to the semester system in 1992 (Haubenstricker & Feltz, 1999).

Original Research Study Methods

Data were collected in four primary categories: physical growth and maturation, motor competence, physical fitness, and a follow-up study. PI Seefeldt selected the variables to be assessed within each category based best practices at the onset of the study (Haubenstricker & Feltz, 1999). Methods of each category are described in the following text. Participants were assessed in June-July and December-January of each year. Data collectors, many of whom were students, underwent a rigorous training protocol supervised by PI Seefeldt and were shown to have high inter-rater reliabilities among measures.

Physical Growth and Maturation

Growth measures were assessed in children 2.0 years and older. Measures were chosen by PI Seefeldt based on best practices at the onset of the study, feasibility for longitudinal study, and consistency purposes. When possible, measures were taken at six-month intervals, primarily June/July and December/January.

Weight. Weight was measured once to the nearest 0.1 lb using a standard mechanical beam scale and was later converted to kg. Participants were barefoot and wore lightweight clothing.

Standing Height. Measurements were taken with the participant standing against the wall. Participants were barefoot and wore lightweight clothing. Heels were placed together, in contact with the wall. Hands were allowed to hang freely at the sides. The head was positioned in the Frankfurt plane. The sliding bar of the anthropometer was brought down, without pressure, on the vertex of the skull. Participants' height was measured once to the nearest 1 mm using a two-meter, metal anthropometer (GPM, Switzerland).

Sitting Height. The participant was seated on a thirty centimeter bench, with his/her back against the wall. The participant assumed the sitting position by first leaning forward and then sliding as far back as possible before sitting upright. The feet were placed so the thighs were perpendicular to the trunk and parallel to the floor. Head, and anthropometer positions were identical to those for standing height, and one measure was taken.

Acrom-Radiale (Upper Arm Length). This measure was taken once with the left upper arm hanging free, and the forearm flexed at 90 degrees across the chest, from the lateral margin of the acromion process to the groove between the lateral condyle of the humerus and the head of the radius using a bow caliper.

Radio·Stylion (Lower Arm Length). With the left upper arm hanging free and the forearm flexed at 90 degrees across the chest with the palm facing toward the body, this measure was taken once from the groove between the lateral condyle of the humerus and the radius to the tip of the styloid process of the radius using a bow caliper.

Biacromial (Shoulder) Breadth. The participant stood with his/her back to the examiner. The acromion processes were first palpated with the index fingers. The olive bulb on one end of the bow calipers was placed just to the left of the left acromial process. The olive bulb on the free end was moved until it was just to the right of the right acromial process. The caliper was held so that the ends pointed up slightly. No pressure was applied, and one measure was taken.

Bicristal (Hip) Breadth. The participant stood with his/her back to the examiner. The iliac crests were located by palpation. The points of the bow caliper were placed on the lateral side of each crest and pressed firmly in order to depress the fat over the bone, and one measure was taken.

Thigh, Calf, and Arm (Biceps) Circumferences. Circumferences of the thigh, calf, and arm were taken on the left side of the body, one time each, with a metal tape just fitting the skin and not compressing either the skin or subcutaneous tissue. For the thigh measure, with the weight of the participant on the right foot, researchers placed the left extremity on a bench so that the thigh was parallel to the surface. The circumference mid-way between the proximal and distal ends of the femur was measured. For the calf measure, with the lower extremity in the position for measuring the thigh, the maximum bulge of the calf was measured. The arm measure was taken at the maximum bulge of the biceps muscle with the arm hanging freely at the side.

Triceps, Sub-Scapular, and Umbilical Skinfolds. All skinfold measurements were taken on the left side of the body. All values were read to the nearest millimeter. The triceps skinfold was assessed over the triceps muscle midway between the olecranon process of the ulna and the acromial process of the scapula, with the skinfold parallel to the longitudinal axis of the arm. The sub-scapular skinfold was assessed one cm below the inferior angle of the scapula, following the natural cleavage of the skin. The umbilicus skinfold was assessed as a vertical fold taken about 2-3 cm lateral to the umbilicus. Early in the study, three measures were taken at each site and averaged. Over time, as the number of participants grew, the average of two measures was taken. For approximately the last 20 years of the study, one measure was taken at each site.

Skeletal Age. For the first seven years of the study (through 1975), hand-wrist radiographs were taken each summer to assess skeletal age. Radiographs were assessed using the Greulich-Pyle technique by PI Seefeldt.

Age at Menarche. In November 1978 a letter was sent to MPS participants' mothers asking for age at menarche for themselves and their participating daughters. Participants responded between November 1978-February 1979.

Motor Competence

Motor competence was assessed in children five years and older. All assessments were video recorded using two cameras (front and side views) and scored later by PI Seefeldt and Co-I Haubenstricker. A system of developmental sequences was created for the study in order to classify stage of development for each skill (Seefeldt & Haubenstricker, 1982). Throwing and catching included five stages of development. Kicking, punting, striking, jumping, running, and hopping included four stages of development, and galloping and skipping included three stages. Skills were performed two-to-five times, depending on the specific skill. Locomotor skills were generally filmed for one-to-three passes, while object control skills were filmed for three-to-five trials. For all skills, a demonstration was provided prior to the participant's attempt. A description of each skill is provided in the following text.

Throwing. Participants were instructed to throw a ball as far as they could. Younger children used a tennis ball, and older children used a baseball/softball.

Catching. Children were instructed to catch a ball when it was lobbed to them. Younger children caught a larger ball (playground size). The size of the ball was smaller with age, and the oldest children caught a tennis ball.

Kicking. Participants were instructed to kick a playground ball as far as possible. The ball was stationary prior to the kick.

Punting. Participants were instructed to punt a playground ball by holding the ball and punting forward as far as possible.

Striking. A ball was lightly tossed to the participant, who would strike it. Younger children used a light playground ball, while older children used a baseball/softball. Younger children were also assessed from a stationary tee.

Jumping. Participants completed a standing broad jump, jumping forward horizontally as far as they could.

Running. Children ran across the gymnasium (approximately 30 feet). Footage from the middle of the performance was assessed to allow for attainment of velocity at the beginning, and children often broke form at the end.

Hopping. Participants hopped on one foot for five-to-fifteen feet, depending on ability. Participants were allowed to try both feet and be tested on the side of their choosing (often the dominant side).

Galloping. Participants galloped across the gymnasium using each leg as a lead leg on subsequent passes. They were instructed to "show their best gallop".

Skipping. Participants were instructed to "show their best skip" as they skipped across the gymnasium.

Physical Fitness

Flexed Arm Hang. One trial of the flexed arm hang was administered to assess upper body muscular strength and endurance. Participants were positioned in a bent-arm hang with elbows flexed at 90° using a pronated grip. Participants were instructed to hang in the bent-arm position for as long as possible. When the elbows reached a position of less than 90° flexion or the participant's chin rested on the bar, time was stopped. Time in seconds was retained for analysis.

Flexed Arm Hang/Weight. To control for participant weight relative to flexed arm hang time(s), the flexed arm hang/weight variable was calculated at all time points in which flexed arm hang score and weight were both available. Participants' average flexed arm hang time was divided by weight (kg) and retained for analysis.

Jump and Reach. The jump and reach test was administered to examine leg power and body coordination. Participants were instructed to stand flatfooted with the preferred side next to a wall on which a jump board was affixed. With the preferred arm, the participant would reach as high as possible and a researcher would record standing reach height. Using a standing jump, the participant jumped vertically and touched the board. The difference between the height attained on the jump and standing reach height in cm for three trials was recorded. The best distance jumped across the three trials was retained for analysis.

Standing Long Jump. The standing long jump was assessed to estimate leg power and body coordination. Participants began with their toes behind a line and were instructed to jump as far as possible from the static position. Three trials were completed but were only counted if the participant took off and landed on two feet. The best performance (cm) from take-off line to the heel of the foot nearest the take off line across three trials was retained for analysis.

Standing Long Jump/Height. To control for participant height relative to jump distance, the standing long jump/height variable was calculated at all time points where standing long jump distance and height were both recorded. Participants' average standing long jump (cm) was divided by height (cm) and retained for analyses. This variable can be interpreted as a percent (e.g., distance jumped as a percent of height).

Agility Shuttle Run. The agility shuttle run was used to assess speed and ability to change direction. Two wooden blocks (chalkboard eraser size) were placed side by side on a line 30 ft (9.14 m) from a parallel starting line. Time began as soon as movement was initiated. Participants were instructed to sprint to the left block, pick it up, turn around and sprint back to the starting line and place the block on the floor, sprint to the right block, pick it up, and turn around and sprint past the starting line with the block in hand. The best of two trials recorded to the nearest 0.1 sec was retained for analysis.

30-Yard Dash. Speed was assessed using the 30 yd (27.43 m) dash. Two sets of cones were placed 27.43 m apart with a 4.57 m starting distance behind the starting line/cones. Participants were instructed to run as fast as possible from the beginning of the starting distance past the second set of cones (finish line). The score was the time in seconds elapsed between the start line and finish line. The best time between the two trials was retained for analysis.

Endurance Shuttle Run. The endurance shuttle run was used to assess lower body muscular endurance and cardiovascular endurance. Two cones were placed 40 ft (12.19 m) apart. Participants were instructed to run 5 laps around the two cones; the time it took the participant to run the 5 laps (121.92 m) was recorded to the nearest 0.1 sec and retained for analysis.

Wells Sit and Reach. The sit and reach test was used to measure hamstring extensibility and lower back flexibility. Participants sat on the floor with the soles of the feet in contact with the back of the sit and reach apparatus, which had a standard ruler affixed to the top of the apparatus. With one hand on top of the other, the participant was instructed to slowly reach and relax three times and then to reach and hold on the fourth reach. The retained score was the distance reached to the nearest 0.5 in (1.27 cm) in relation to the vertical surface of the bench touched by the feet. The best of three trials was retained for analysis.

Dynamic Balance Test. For the first seven years of the study, dynamic balance was assessed. Children were timed while they walked across a pentagon structure comprised of wooden 2" x 4" x 8' planks (complete circuit was 40 feet). Children were instructed to walk as fast as possible and were timed until the first foot touched the ground next

to the structure. This measure was discontinued for two reasons. The first reason was that time of assessment took too long for some children who could maintain their balance on the structure for several minutes. The second reason was that the task was too difficult for many younger children, resulting in several zero scores.

MPS Follow-Up Physical Activity (PA) Survey

As previously mentioned, participants who engaged in at least eight consecutive data collection cycles over the course of the MPS were invited to partake in the follow-up study in 1998. An additional inclusion criterion included being out of the study for a minimum of eight years. Of the total MPS population, 421 were eligible for participation in the study. Surveys were mailed to all eligible participants, and 256 (60.8%) were fully completed and returned. At the follow up data collection, participants responded to a variety of questions concerning demographics, past sport and PA participation, current sport and PA participation, and perceptions of their own PA and of the Motor Performance Study. Each of these sections are reviewed briefly.

Demographic Questionnaire

Participants also answered questions concerning demographic characteristics including gender, age, current height and weight, past health problems and injury history, marital status, and occupation. Participants also responded to questions that provided self-assessments for present health (e.g., excellent, good, fair, poor), present level of PA (e.g., very active, fairly active, average, fairly inactive, very inactive), and present physical fitness level (e.g., above average, average, below average). Finally, researchers asked about participants' number of children, birthdays of children, and gender of children.

Leisure Time Physical Activity

Leisure time PA (LTPA) was assessed by the Minnesota Leisure Time Physical Activity questionnaire (Taylor et al., 1978). The questionnaire lists 90 individual physical activities that fit in one of six major domains of PA (i.e., sports, conditioning exercises, fishing and hunting, home repair, lawn and garden, walking, and miscellaneous). Participants indicated the number of occasions per month during the previous 12 months that they performed each activity and its average duration in minutes. Activities were classified as either light, moderate, or heavy in intensity.

Past Sport Participation

Participants answered questions about their youth sport participation in 35 different sports. These sports included traditional sports such as baseball, soccer, and track and field, as well as non-traditional activities like Karate, Judo, and downhill skiing. Participants were asked to indicate if they played these sports in settings that included free play, recreational sports, intramural sports, interscholastic sports, college intramural sports, and intercollegiate varsity sports.

Participant Perceptions of the Motor Performance Study Experience

A number of questions assessed participant's experience in the MPS and outcomes from participation in the program. These nine questions were scored on a five-point Likert scale (1= strongly agree; 5 = strongly disagree). These questions assessed the experience (e.g., "The MPS was an enjoyable experience"), effectiveness of the MPS ("The MPS taught me a variety of motor/sport skills"), influence of the MPS on attitudes toward PA (e.g., "The MPS positively influenced my attitude toward physical activity as a youth"; "The MPS positively influenced my attitude toward physical activity as an adult"), influence of general self-esteem (e.g., "The MPS helped build my self-esteem"), transferability to other domains (e.g., "The MPS made me comfortable in attempting new activities as a youth"; "The MPS made me comfortable in attempting new activities as an adult"), and value of PA to general well-being (e.g., "The MPS helped me to understand that regular participation in physical activity is important for my well-being"). In addition, participants were asked to rate their willingness to enroll their child in a motor performance activity program if the opportunity were available. Finally, two questions asked participants to self-assess their own motor skills compared to their peer group during high school and currently (1 = superior; 2 = above average; 3 = average; 4 = below average; and 5 = inferior).

Age at Menarche

Female participants were asked to provide information concerning their age of menarche. Specifically, respondents were asked to provide their birthday, the date they entered school, and then age at menarche with specific instructions to be as precise as possible with examples provided (e.g., 12 years, 3 months; summer between 6th and 7th grades). Finally, participants were asked on a scale of 1-5 (1 = unsure; 5 = most sure) for how sure they were about this date. A place for any specific comments was also provided.

Summary

The MSU MPS was conducted for over 30 years and provided a wealth of information regarding physical growth, maturation, motor competence, and physical fitness. Statistical analyses used to interpret the data vary by research question, as one will witness while reading the remaining manuscripts in this special issue.

Acknowledgments

We thank all participants and their parents for their long-standing loyalty to the investigation. We also thank all of the undergraduate and graduate students who spent countless hours participating in the assessments and/or the motor skills instruction.

Disclosure

The authors certify that has manuscript has not been published elsewhere and that it has not been submitted simultaneously for publication elsewhere. The authors do not have any financial conflicts of interest related to the research reported in the manuscript.

References

Haubenstricker, J., & Feltz, D. L. (1999). *100 Years of Kinesiology: History, Research, and Reflections*. East Lansing, MI: Michigan State University Press.

Lee, I.-M., Shiroma, E. J., Lobelo, F., Puska, P., Blair, S. N., & Katzmarzyk, P. T. (2012). Effect of physical inactivity on major non-communicable diseases worldwide: an analysis of burden of disease and life expectancy. *The lancet*, *380*(9838), 219-229.

Malina, R. M., Bouchard, C., & Bar-Or, O. (2004). *Growth, Maturation & Physical Activity*. Champaign, IL: Human Kinetics.

Seefeldt, V. (1980). Developmental motor patterns: Implications for elementary school physical education. In C. Nadeau, W. Holliwell, & G. Roberts (Eds.), *Psychology of motor behavior and sport* (pp. 314-323). Champaign, IL: Human Kinetics.

Seefeldt, V., & Haubenstricker, J. (1982). Patterns, phases, or stages: An analytical model for the study of developmental movement. In J. A. Kelso & J. E. Clark (Eds.), *The development of movement control and coordination* (Vol. 309, pp. 318). New York, NY: Wiley & Sons.

Tanner, J. M. (1981). *A history of the study of human growth* Cambridge, UK: Cambridge University Press.