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Original Article

Comparison of two pre-jump techniques for equal feet take off jump in aerobic gymnastics: a pilot study

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Abstract
Aerobic gymnastics, which is more recent sections of the International Federation of Gymnastics (FIG), requires more research. The research for this discipline is essential because scientific insights into physiology, biomechanics and psychology optimizes performanceand allows athletes to preserve health. The aim of this pilot study is to evaluate the biomechanical pre-jump parameters in equal feet takeoff jumps in aerobic gymnastics. There are two predominant pre-jump techniques: pre-jump with equal feet take off preceded by a flight phase and the pre-jump with equal feet take off without a flight phase. This pilot study aims to better understand the two pre-jump techniques to make a contribution to this research field. The kinematic analysis of the two pre-jump techniques showed a considerable difference, in thejump height and flight time between the preparation for the equal feet take off jump with the flight phase before the crouching and that without the flight phase. This observations prompts us to more closely evaluate the two techniques, because the ability to increase height and flight duration of the jump is decisive for the success of the jumps with greater in flight rotation.
Keywords: aerobic gymnastics, pre-jump techniques, jump, training.

Introduction

Aerobic gymnastics, a discipline its recognition and official inclusion among the International Federation activities dates back to 1994, is presented as a young sporting activity in comparison to the other sections of the International Gymnastics Federation (FIG) which have a long historical tradition and are recognized as Olympic disciplines by the IOC. Aerobics, effectively, is not yet an Olympic sport but,during the first European Games of Baku in 2015, it has been officially inserted in the program of the disciplines by the European Olympic Committee.

From 1994 to the present, numerous changes have been made to the Code of Points, which enabled a considerable technical evolution of this discipline, making it at the same time more objective from the point of view of the evaluation of the performances.

This brief introduction legitimizes the choice to analyze, through scientific studies, a specific aspect of this technical sport of combinations that requires more attention by the world of research. The scientific literature in this specific field, in fact, is limited and confined to a few studies carried out by the federations. The Aerobic Gymnastics Technical Committee of the Gymnastics' International Federation in 2014 published a collection of scientific studies for the purpose of giving visibility to some researches directed in various fields contributing to the improvement of the performance in aerobic gym. For years, technicians and specialists in the field have tried to put in place their own experience to understand the specific movement of aerobics to make increasingly complex and aiming for the perfect execution, proving year after year, an ever higher level of performance. Since the first edition of the Aerobic World Championships in 1995, aerobics has changed considerably; it's clear,to the technicians' eyes, the long and distinctive evolutional path of the discipline that today justifies the need to be subject to the research with the scientific approach, like the other sports (FIG, 2014).

It is evident that studies and researches permit a better acquaintance of the discipline and provide key information to improve the performance, sometimes even putting in evidence the presence of mistakes or wrong formulation in the specific technical / physical preparation.

Also in the branch of the Code of Points, some studies and the results of international competitions, provide interesting grounds for reflection that sometimes involve changes to the code itself or to the technical programs.

The research has become fundamental for this young discipline; the extension of knowledge with

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scientific detailed studies in physiology, biomechanics and psychology not only optimizes performance but allows athletes to keep in health.

The considerations set out above justify the choice of this pilot study that aims to investigate some of the pre-jump biomechanical parameters in equal feet takeoff jumps.

In the code of points the difficulties are divided into four main (which will be discussed later in this paper), including numerous technical elements that belong to the jumps group called "Jumps and Leaps" and that may have a value that may change depending to the difficulty level from 0.10 to 1.00.

The elements of the jumps group have the start which can range from equal feet takeoff or takeoff from one foot, arrivals, instead, may be different: standing, split (frontal or sagittal), to push up (on the four supports or other changes in attitude of the body in push).

The elements of the jumps group are numerous. The changes of the body attitude in flight, the addition of round trips on different floors or the different arrivals, modify the jump to which is assigned a value based on the level of difficulty. Beyond what the athlete can perform during the jump, after the takeoff phase, it is essential to perform with the best technical perfection the pre-jump that strongly affects the subsequent phases of the jump itself.

In the international competitions different preparations to jump are observed. In particolar, the two predominant pre-jump techniques are:

- Pre-jump with equal feet take off preceded by a flight phase
- Pre-jump with equal feet take off without flight phase

Some differences of approach are also noticed on the occasion of the federal rallies and this often leads to confusion not only in technician, but especially in athletes who are trying to find the best solution for the perfect performance. The studies carried out in this specific field are very limited. Through internet can be seen some abstracts of Chinese origin who have studied the pre-jump phases, but unfortunately the extensive items of this research are not downloadable.

This pilot study, therefore, aims to evoke a scientific reflection on the two pre-jump techniques in order to make a contribution to this research field.

Background

As highlighted in the introduction, aerobics is a sport that only recently obtained proper recognition at the international level. The recent participation in the European Olympic Games has finally placed in the foreground even aerobics along with the more traditional Olympic disciplines of rhythmic and artistic gymnastics. This important and deserved place among the Olympic disciplines, even though for now only in Europe, is the first step to start a more scientific discourse, and further promote research also in aerobics.

Unfortunately, the scientific studies are still limited, so the technical choices often follow the trends of other countries. The specific literature is limited to a few studies carried out by some national federations, and the largest number of publications is found in China, but in recent years there has been an increase of interest in this discipline also by the academic world that, through a series of studies, started the scientific discourse in aerobics.

The first collection of "Scientific Research studies in Aerobic Gymnastics" published by the Fédération Internationale de Gymnastique in 2014, which summarizes the latest studies carried out in this sport, demonstrates the growing interest and the will to disseminate and promote research.

This publication was intended to give visibility to some research conducted in different fields contributing to the improvement of the performance in aerobics.

Within the collection in the section dedicated to the technical aspects of the difficulties, it is interesting the biomechanical analysis of some of aerobics specific jumps (Moreira Lemos et al., 2014). The Brazilian study compared, in terms of height of the center of mass, the total contact time with the ground and the maximum force, three different jumps (two typical jumps of Aerobics COP: Straddle Pike Jump and Jump) and a standardized jump (Drop jump), depth jumps commonly used in the specific physical preparation for the jumps.

The study shows that the specific training with Drop Jumps could lead to a decrease in the time of contact with the ground during crouchingand thus improving not only performance but also the arrivaltechnique of the jump with reduced risk of injury.

However, a study of performance models in aerobics is Italian (Righetti, 2009). The research analyzed the morphological characteristics and the recent training characteristics of the athletes by comparing them with the results of previous studies. The sample of athletes was subject to evaluations of the posture and the balance. The mechanical characteristics of the muscles have been analyzed also in relation to some technical jumps comparing different sexes, different ages and different levels of performance.

In conclusion, the study shows that, despite the considerable changes in the Code of Points, in the muscular characteristics of the elite athletes, compared to previous studies, there are no major differences; on the contrary the metabolic aspects are significantly changed with an increase in the intensity of the performance.

A Chinese study (Yan Zhi -pu et al., 2006) analyzed the vertical jump with the video analysis noting in particular the parameter of the vertical speed and the contact time with the ground before the takeoff. For Chinese athletes the contact time in crouching is lower to allow the development of more vertical speed, but the study shows that the vertical speed is strongly influenced by the strength of the athlete's legs.

Even a kinematic study of the Straddle Jump to push up, a difficulty of the jumps family, (Li Shiming et al., 2010) analyzes all the kinematic aspects at the different stages of the jump.
In literature, currently, there is only one study that analyzes the pre-jump in aerobics (Zi Xin Zhu, 2014) highlighting the crucial importance of this technical aspect for the quality of the jump.
In fact, it is a crucial element for the success of the high-value jumps in Code of Points. The Chinese research analyzes the kinematic mechanisms of the pre-jump explaining the importance of preparation to the jump and highlighting the crucial role of the biomechanical analysis to analyze the forces produced in the takeoff process. .
The factors that affect the vertical force in the pre-jump have been analyzed, proving that the weight, the length of the legs, the knee angle significantly affect it.

Aim

The aim of this pilot study is to evaluate the biomechanical pre-jump parameters in equal feet takeoff jumps in aerobic gymnastics.
The kinematic analysis allows us to compare the differences between the two different techniques in terms of quantity (jump height, time of contact with the ground, the knee joint crouching angle).

The biomechanical analysis of technical movements allows, through the study of the data generated by the descriptive statistics, a reflection and a scientific interpretation of the values aimed at improving the jumping technique.

Methods

Sample

N. 4 agonist gymnasts of the senior class of the aerobic gymnastics (n.2 female n.2 male), aged between eighteen and twenty-two, took part in this study. All of them are members of Italian Gymnastics Federation (FGI) affiliated companies in the Campania region.
The athletes were members of the National Aerobics Gymnastics Team of FGI and took part in the European Championships in 2013. Before starting the study, the participants were made aware of the ways of carrying out the tests and tests planned for them. Participants also signed the consent to the processing of personal data according to the privacy policy.

Video camera

Jumping performances have been taken from a HERO4 Black camcorder. This is a HD video camera that offers an amazing slow motion mode up to 240 frames per second. For the purpose of this study, high-resolution 4K30 and 2.7K60 video mode and high frame rate of 1080p90 were used, which allowed to record 90 frames per second. (Table n.1)Athletes did their performance in a calibrated space. The camera was placed on the sagittal plane to the athletes on a fixed plane with the Go-pro locking instrument. The videos, that have been realized, have been analyzed through the Kinovea ver. 08.15. Video analysis software.

Kinovea software

Video analysis is a method of evaluating the movement that can be very useful in sports. Using video analysis software, the operator is able to visualize and process the desired parameters, objectifying and realizing a scientific and reliable study of the gesture taken into account or on a given sequence of actions. The analyzed subject is completely free from any constraint; the only equipment that you can use is sticky markers to be placed on joints, sternum or other reference points. The instrument features one or two digital cameras that allow us to analyze the same gesture from multiple angulations and with different speeds to highlight the detail that almost always escapes to a naked eye examination.
It can be useful for both didactic purposes (allowing the athlete, beginner or professional, the great advantage of being seen on the screen by taking into account postural aspects, taking into account sometimes unknown body patterns, facilitating the already automated gestures and the learning of new motor skills, accelerating learning processes) and for the technical level for coaches (improving the biomechanical knowledge of the technical gestures needed to refine teaching / learning procedures and to develop new training strategies) . Video processing can be transformed into image files, to allow the easy insertion into presentations, report documents, athlete cards.

In addition, the program allows to transform the video of the athlete's analysis into easily readable moments, with written comments, so the attention will be focused on specific moments. The zoom function allows to analyze technical details and to fix accurately distances and angles; the times of the different stages of the technical operation can be calculated accurately using the chronometer.

Procedures and protocol of study

The athletes who took part in the study are experienced ones who have been doing both the pre-jump techniques for years and therefore have automated both crouching modes.

The athletes were weighed and measured in height. Before doing the performance, the gymnasts performed a standard warm-up of about fifteen minutes (general activation, pre-athletic and quadruped, dynamic stretching).

Before carrying out the tests provided by the study, athletes performed jumping progression by alternating the two different jump preparation techniques. It has been specified to make jumps along the dotted

line in the video detection space and the central line, on which to crouch the jump, has been shown. Each athlete performed a total of two valid try for each test. All the athletes performed the jumping test in the same day at 6pm. Indoor plant with wooden surface (parquet). The 24 ° climate was optimal for the conduct of the tests.

Anatomical landmarks

For specific detection of knee joint crouching angle and jump height, some markers were placed on the following landmarks:

- Greater trochanter
- Knee joint rotation center
- Side Malleol

Space calibration

Before doing the performances, space calibration was performed by:

1- Positioning of the camera transversely to the jump line
2- Measurement of the distance and of the height of the camera
3- Measurement of the jump line with the horizontal calibration (by means of a calibration bar of 1 meter length)
4-video with vertical calibration (by means of a 1-meter calibration bar) and positioning of the gymnast (with the fixed markers on the anatomical landmarks) in the jump area.

These procedures are followed by video capture with vertical calibration and markers in the pc, saving key images. (Fig. 1-2)

Analyzed jumps:

Athletes performed the following jumps:

- Tuck Jump (TJ)
- Cossack Jump (CJ) (Fig.3)
- Straddle Jump (SJ)

The three jumps were executed no. 2 times for each type of technique.

Pre-jump techniques

- With flight phase before crouching on equal foot
- Without flight phase before crouching on equal foot

For each performed jump, the following phases, common to all jumps, have been taken into account:

1 - Starting position
2 - Step
3 - Crouching
4-step detachment (start of flight phase)
5 - Maximum jump peak
6 - Contact with the ground (end of flight phase)
7 – Landing
8 - Final position

From the analysis of the above mentioned moments of the technical gesture, the following data were collected:

- Knee crouching angle
- Jump height
- Flight time

The three parameters were analyzed for all the performed jumps by comparing the values between the two different jump preparations.

Analysis of data

All quantitative data were computerized and processed using SPSS v.21 software. Six jumps (2 tuck jump, 2 straddle jump, 2 cossack jump) were analyzed for each type of technique (T1 - with flight phase and T2 - without flight phase before the closure on equal feet), after checking that there were not differences between the two tests. No.36 videos were subjected to video analysis and then they were analyzed with Kinovea software. The data are presented in a table with mean ± standard deviation and, before the analysis, they were checked to verify the normality of distribution (Shapiro-Wilks test).

For the statistical test, a mixed model (within subjects) of ANOVA (variance analysis) was used with factor within the two pre-jump mode (T1 and T2) and factor between the three types of jump (tuck, straddle,and cossack). Three separate tests were carried out for each object variable of the study (jump height, flight time, and knee angle).Statistical significance was accepted for $p \leq 0.05$.For more clearness, see the table n. 2,that highlights the legend for the interpretation of the results.

Results

The results are reported in:

- No.1 synthetic table comparing the various pre-jump techniques (T1-T2) for the three variables (table n.3)
- No. 6 charts - two for each of the analyzed variables, one of which displays data comparison between the three different types of jumping, the other with the only comparison of the two pre-jump modes for all types of made jump. (Fig. 4-9 in the appendix)

Discussion and conclusion

Jump height analysis

The main effect of the pre-jump type was significant (p = 0,001, eta squared0,544) with a higher reach in all the jumps with pre-jump with flight phase 53.56 ± 8.65 cm) compared to the one without flight phase (50.09 ± 8.28 cm).No significant interaction between pre-jump type and jumping technique.

Flight time analysis

The main effect of the pre-jump type was significant (p = 0.023, eta squared 0.339) with greater flight time in all the jumps with pre-jump with flight phase (0.599 ± 0.055 s) compared to that without flight phase (0.585 ± 0.055 s). No significant interaction between pre-jump type and jumping technique.

Knee angle analysis

The main effect of the pre-jump type was not significant (pre-jump with flying phase = 98.06 ± 7.02 degrees, pre-jump without flight phase = 97.94 ± 5.34 degrees).The interaction between pre-jump and jump technique was significant (p = 0.030, eta squared0.417). As post-hoc analysis, the cases were split up by jumping technique and repeating the comparison between the two pre-jump modes.The difference between the two pre-jump modes was significant only for the Straddle technique (p = 0,045, eta squared= 0,585) with a knee angle more open (94.00 ± 4, 58 degrees) in pre-jump mode compared to the one without (99.00 ± 3.46 degrees).The kinematic analysis of the two pre-jump techniques showed a considerable difference, in the jump height and flight time, between the preparation for the equal feet take off jump with the flight phase before the crouching and that without the flight phase.

This fact invites us to reflect on the need to look more closely at this comparison of techniques, because the ability to increase quantitatively the aspects of height and flight duration of a jump is decisive for the success of jumps with greater in flight rotation; such as more the complex jumps that allow the athlete to put in the routines higher technical value elements, thus increasing the score of the difficulty. Considering the speed of the technical gesture, kinematic analysis could be carried out with high tech equipment that would allow capturing high-speed video with a greater number of frames per second. Our analysis was done at 90 frames, but it would have been ideal for a higher level of precision to analyze the considered parameters.In the first project of the study there were planned jumps with rotation to test also on technical features of greater value the quantitative responses of the two different techniques, but the problem of early body rotation in the pre-jump phase during the closure of the feet in flight, before the crouching, did not allow to detect the selected data. To carry out these tests we would need a longer period of assimilation / training of the two different jumping techniques with higher rotation and difficulty level. It would be interesting, in the light of such reflections, to develop a search on a larger sample of gymnasts by scheduling a technique assimilation period and subsequently a video analysis not only on jumps but also on jumps with longitudinal axis rotation. Scientific literature in the sport of aerobic gym is still very limited and in some cases superficial and unreliable. It is evident that there is a need to increase scientific studies and to share them for the technical improvement of this discipline and to achieve the recognition of aerobics among Olympic sports.

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Appendix

Table n.1 Features of the HERO 4 video camera – GoPro

RESOLUTION	FPS	FIELD OF VIEW
1080p	90	Ultra wide
Camera Position		
• Sagittal to the athletes		
• distance: 4,85 m.		
• Height: 1 m.		

Data matrixlegend	
Prejump with flight phase technique	T1
Prejump without flight phase technique	T2
Tuck jump - prejump with flight phase	TJ T1
Tuck jump - prejump without flight phase	TJ T2
Cossack jump - prejump with flight phase	CJ T1
Cossack Jump - prejump without flight phase	CJ T2
Straddle jump – prejump with flight phase	SJ T1
Straddle Jump – prejump without flight phase	SJ T2
Jump height (cm)	H (cm)
Flight time (s)	Flight time (s)
Angle of knee joint crouching	^ Knee angle (°)

Table n.2 – Data matrix legend
pre-jump with equal feet take off preceded by a flight phase and the pre-jump with equal feet take off without a flight phase.

	T1WITH phase of flight	T2WITHOUT phase of flight
	Media±ds	Media±ds
Jump height (cm)		
Tuck	51,18 ± 8,66	47,87 ± 7,04
Cossack	50,86 ±11,05	48,09 ± 11,18
Straddle	57,73 ± 6,52	53,64 ±7,55
Flight time (s)		
Tuck	0,59±0,051	0,58 ± 0,051
Cossack	0,58±0,055	0,57 ± 0,064
Straddle	0,62±0,060	0,61 ± 0,055
Angle of knee joint crouching (°)		
Tuck	100,5 ±9,42	96,5 ±6,74
Cossack	99,5 ±5,07	100 ± 4,24
Straddle	94,67 ±4,59	98 ± 4,82

Table n.3 - Comparison between two techniques (T1-T2)

Fig. 1 Calibration of space

Fig. 2 Vertical calibration

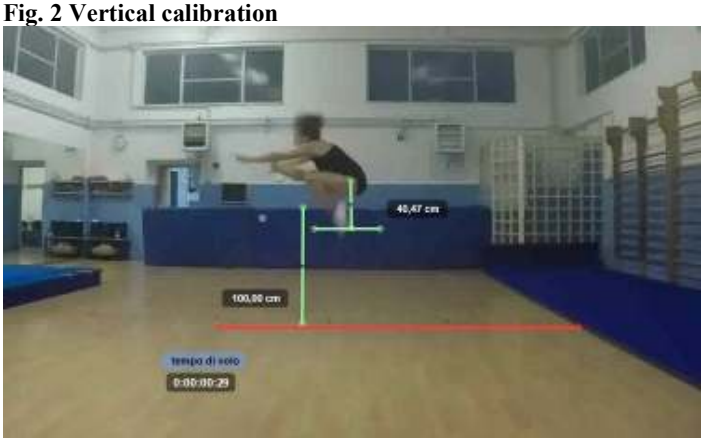

Fig. 3 Cossack jump

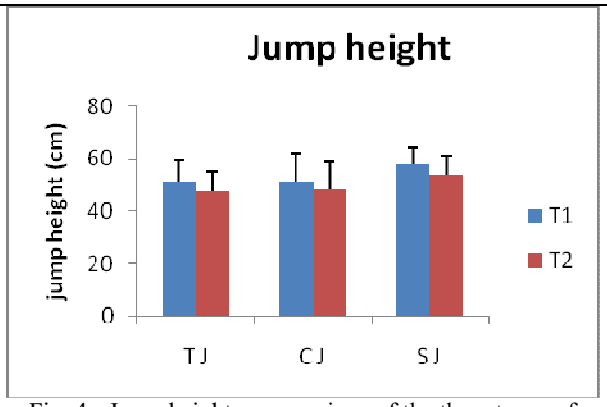

Fig. 4 - Jump height - comparison of the three types of jumping

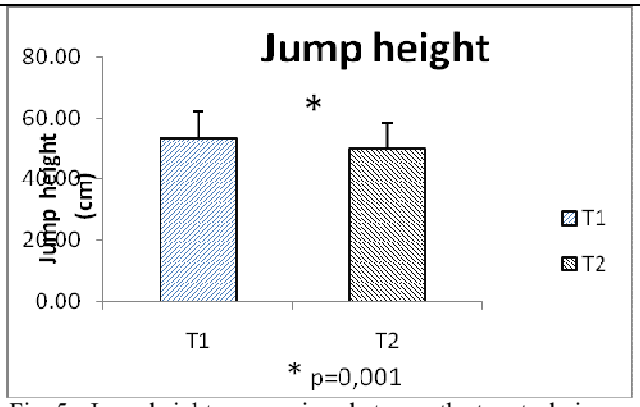

Fig. 5 - Jump height- comparison between the two techniques

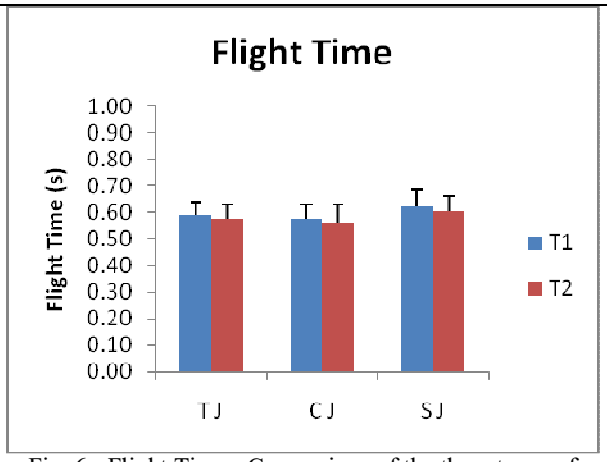

Fig. 6 - Flight Time - Comparison of the three types of jumping

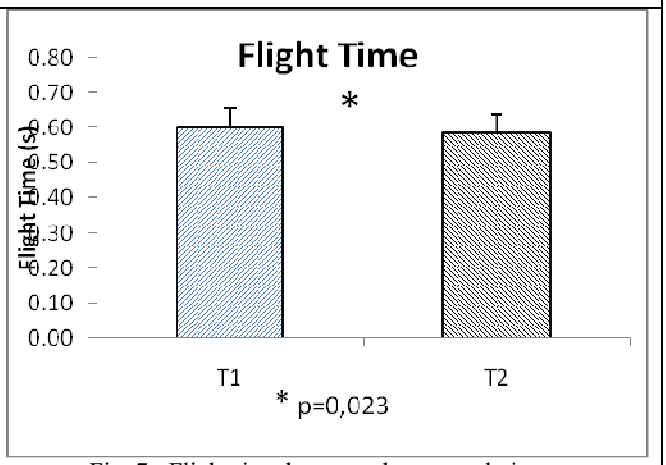

Fig. 7 - Flight time between the two techniques

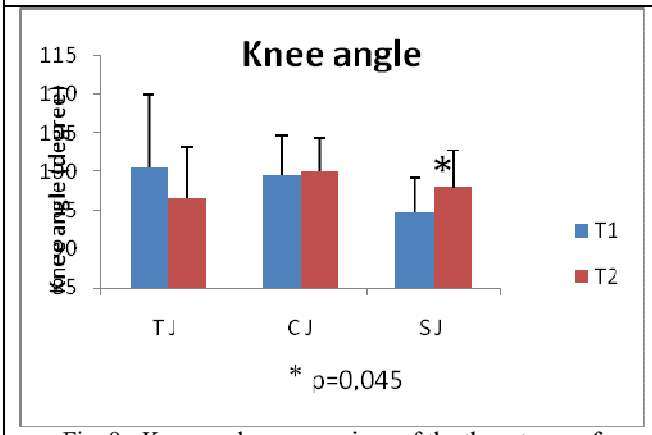

Fig. 8 - Knee angle - comparison of the three types of jumping

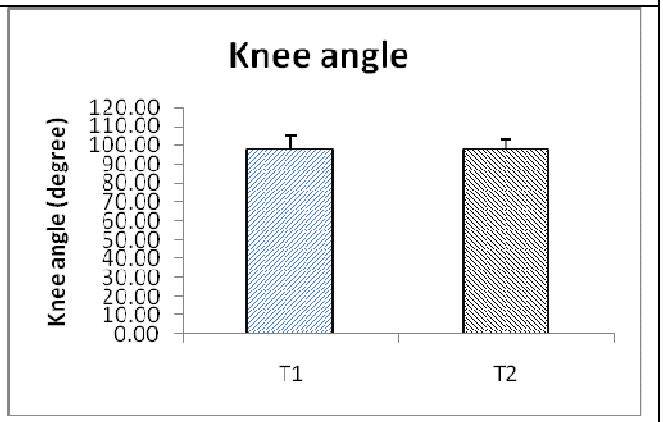

Fig. 9 - Knee angle - comparison between the two techniques