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Content of a warm up programme for instrumental musicians: A Delphi study

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Abstract. The role of warm up or physical exercise in the prevention of Playing Related Musculoskeletal Disorders (PRMD) among instrumental musicians has been identified over the years. However, its role could not be ascertained probably due to the non – standardised practice and pattern of the warm up exercise and physical exercise. Stretching is usually considered as a physical warm up whereas the mode and type of stretching is not usually specified. The aim of this study is to determine the content of a warm up exercise programme for instrumental musicians. This is a Delphi study and it was conducted in three phases. Experts with experience in the field of music, research and managing injuries of the performing artists, were purposively selected to be members of the panel via the Performing Arts Medicine Association (PAMA) member directory. Seven experts in the performing arts medicine participated in the study. The content of the warm up program using the Delphi study includes stretching exercises and musical warm up prior to playing while strengthening and conditioning should be done thrice a week.
Key words: *physical exercise, musculoskeletal disorders, instrumental musicians*.

Introduction

The role of warm up or physical exercise in the prevention of PRMDs among instrumental musicians has been identified over the years (1, 2). However, its role could not be ascertained probably due to the non – standardised practice and pattern of the warm up exercise and physical exercise. Stretching is usually considered as a physical warm up whereas the mode and type of stretching is not usually specified (3). A standardised exercise programme was found to reduce physical exertion while playing a musical instrument and this was found to reduce the incidence of PRMDs among an orchestra group (4). In sports, especially football, standard warm up exercise programme has been found to be beneficial in the reduction of musculoskeletal disorders (5, 6). Therefore, a well-planned and standardised warm up exercise programme could reduce the incidence of PRMDs among instrumental musicians.

The aim of this study is to determine the content of a warm up program as an injury prevention strategy to prevent PRMDs among instrumental musicians. This paper is focussed on the Delphi study which was used to design the warm up program.

Material and Method

The Delphi study which involves the use of questionnaire to collect to reach a consensus on a selected subject matter is best suited for this study. The Delphi process as discussed by Skulmoski, Hartmann, and Krahn, (7), in a three round Delphi process involves, develop the research question, design the research, research sample, develop Delphi round one questionnaire, Delphi pilot study, analyse round one result, develop round two questionnaire, release and analyse round two questionnaire, develop round three questionnaire, release and analyse round three questionnaire, verify and generalize research results. A Delphi study which was conducted in three phases was used to determine the content of the warm up program. The Delphi study was used to obtain an informed consensus from a group of experts in the performing arts medicine selected across the world from the PAMA directory. Consensus was set at 65 % of the respondents.

Participants were experts with experience in the field of music, research and managing injuries of the performing artists as recommended by Anderson and Schneider (8). They were purposively selected to be members of the panel via the PAMA member directory.

Written informed consent was obtained from each of them. The criteria for selection into the Delphi study were researchers and clinicians involved in the performing arts medicine anywhere in the world. Participants were sent an e-mail requesting their consent to participate in the Delphi study.

Twenty experts in the field of performing arts medicine were invited for this study. These included medical doctors, physiotherapists, an occupational therapist, an exercise physiologist and professional musicians; all were either involved in performing arts medicine research or treatment of the performing artists. Their background diversity allows for different views on the subject matter and this increases the quality of the study (9, 10).

Fourteen (70 %) responded, to the request, of these, six (6) gave various reasons for not being able to participate in the study. These reasons were mostly time constraints. However, eight of the experts agreed to participate in the study.

Although, eight experts agreed to participate in the Delphi study, only seven responded with their details regarding occupation, areas of specialty and years of experience.

Anonymity of the participants was ensured. The details of these experts are summarized in Table I. The mean number of years of practice experience in the performing arts medicine was 9.14 years (3 – 12 years). 85.71 %, six of the participants are involved in the treatment and research in the performing arts medicine while 14.2 %, one of the participant is a freelance musician. This includes three medical doctors, two physical therapists and one occupational therapist.

Table I. Characteristics of panel of experts

Occupation	**Years of experience**	**Speciality**	**Focus in the performing arts**
Occupational Therapist	11 years	Occupational Therapy	Musicians' injuries, upper extremity, occupational health
Medical Doctor	6 years	Sports Medicine, performing arts medicine, physical medicine and rehabilitation	Dance injury prevention
Freelance Musician	10 years	Bassoon and chamber music	Research health of wind instrumentalists
Physical Therapist	10 years	Performing arts medicine	Musculoskeletal injury of instrumentalists
Medical Doctor	12 years	Consultant rheumatologist	Musculoskeletal problems
Medical Doctor	12 years	Orthopaedic surgery	Dance (ballet)
Physical Therapist	3 years	Physical therapist/hand therapist	Stress management and health promotion

Method. A self-administered questionnaire was designed; the questionnaire was reviewed by two independent researchers for face and content validity which led to minor changes being made. The questionnaire contains both open and closed ended questionnaire, with the aim of seeking new information and establishing existing information (11-13). The questionnaire is a nine item questionnaire with the first question determining to know the years of experience and primary occupation and specialty of the participants. The remaining questions broods on the content of the warm up programme: type of exercise, duration, area of body to be "warmed up", inclusion of musical warm up in the programme and education on injury prevention strategies. The results of the systematic review informed the content of the questionnaire. Table II outlines the questions included in the questionnaire.

Table II. Content of the survey questionnaire

Item	**Description**
1	What is your occupation, area of specialty and years of experience?
2	Which of the following should be included in the warm up injury prevention program: stretching, aerobic exercise, strengthening and conditioning?
3	Should instruction on the correct technique of item 2 be included in the program?
4	Should musical warm up be included in the warm up programme?
5	What should be the duration of the warm up programme per session?
6	Describe the frequency of the warm up programme?
7	Which region of the body should the warm up programme, be focused on?
8	Which of the following education topics on injury prevention should be included in the warm up injury prevention program? Education on: breaks, body mechanics and posture, warm up, recognition of risk factors, cool down, stress reduction, strengthening, conditioning, increasing practice load gradually and physical limitation when choosing repertoires
9	What is your opinion on the mode of instruction of Item 8?

*Data Collection and Procedure***.** The survey was conducted using Survey Monkey, an online survey site that can be used to design, collect and analyse surveys.

The 9 – item questionnaire was sent as a link to the eight experts individually, anonymity was ensured.

Aggregating results is highly subjective (14) and some studies have placed consensus at 100 % (15) while others are less specific (16), however for this study, consensus was set at 65 %.

Results

First Round of Delphi study

The response rate for the first round of the Delphi study was 87.5%, seven of the eight participants responded. Consensus was reached on two items on the survey. All (100%) the participants agreed that the correct technique of the warm up program as an injury prevention strategy should be taught. Consensus was also reached on the inclusion of musical warm up as part of the warm up exercise programme. The result of the first round of the Delphi study is further illustrated in Table III.

Table III. Results of First Round of Delphi Study (n = 7)

Item	Agree	(n)	Opinion
2 Content of the warm up program			Postural awareness
Stretching	85.7%	6	
Strengthening	85.7 %	6	
Conditioning	71.4%	5	
Aerobic exercise	57.1%	4	
3 Correct technique	100 %	7	
4 Musical warm up	71.4 %	5	
5 Duration of warm up			
5-10 minutes	42.9 %	3	
10 – 15 minutes	42.9 %	3	
15 – 20 minutes	14.3 %	1	
6 Frequency of the program			
Warm up before every practice session	85.7%	6	
Conditioning (three times / week)	28.6 %	2	
Warm up (four times / week)	14.3%	1	
7 Focus of the warm up on body region			
Whole body	57.1 %	4	
Upper extremity, back and neck	42.9 %	3	
Back	28.6 %	2	
Lower extremity	14.3 %	1	
Upper extremity	14.3 %	1	
Neck	14.3 %	1	
Back	14.3 %	1	
8 Education on Injury prevention			
Breaks	85.7 %	6	
Body mechanics and posture	85.7%	6	
Warm up	85.7%	6	
Increasing practice load	71.4 %	5	
Recognition of risk factors	57.1 %	4	
Cool down	57.1 %	4	
Stress reduction	57.1 %	4	
Physical limitation	57.1 %	4	
Strengthening	57.1 %	4	
Conditioning	57.1 %	4	
Light practice when fatigue	42.9 %	3	
9 Mode of instruction of Item 8			
Classroom	100 %	7	
One on one	100 %	7	Active learning and group instruction and reinforcement by teachers.
Hand-outs	85.7 %	6	
Internet	42.9 %	3	
Television	0 %	0	

On the content of the warm up programme, the inclusion of conditioning, stretching and strengthening as part of an injury prevention programme was agreed on by the participants; aerobic exercise was excluded from the content of the warm up programme. However, postural awareness was suggested by one member of the panel as part of the warm up programme. Physical conditioning and core strengthening were suggested by two members of the panel to be included as an injury prevention program to be done on a more regular basis outside the warm up programme. Consensus was not reached on the content of the warm up programme in the first round of the Delphi study. This was further considered in the second round of the study. Consensus was not reached on the duration of the warm up programme prior to practice or playing, as 42.9 % of experts agreed on 5 - 10 minutes and 10 - 15 minutes while 14.3 % agreed on the duration of the warm up to be 20 minutes. The duration was further considered in the second round of the study. Experts were asked to, 'Describe the frequency of the program?' All the participants gave their various suggestions on the frequency and duration of the warm up exercise before practice or playing. The various opinions are further considered in the second round of the study. Consensus was not reached on the region of the body on which the warm up exercise programme should be focused on. Majority of the experts agreed on the focus of the warm up programme to be on the whole body (57.9 %), while the neck, head and lower extremity have the least scores (14.3 %). On the content of the injury prevention education topics, consensus was not reached on the content of the injury prevention education programme, importance of avoiding fatigue or doing light practice when fatigued was not agreed upon to be included in the education programme. This was further considered in the second round of the study.

Participants were asked about their opinion on the mode of instruction of the education topics and consensus was reached on classroom, one on one and the use of hand-outs as a mode of instruction. Active learning and group instruction in classroom were suggested by two participants respectively and this was further considered in the second round of the study.

Second Round of Delphi Study

The second round of the study however focuses on the emerging opinions and the various other areas where consensus was not reached in the first round. The survey in the second round was structured based on the response of the first round. Six out of the eight participants responded to the survey of the second round of the Delphi study. Table IV illustrates the results of the second round of the Delphi study.

Table IV. Second round of the Delphi study (n=6)

Item	Agree	(n)	Opinion
1 Content of injury prevention			Nutrition
Stretching	100 %	6	
Postural awareness	100 %	6	
Strengthening	83.3%	5	
Conditioning	83.3%	5	
2 Warm up should be done prior to playing	100 %	6	
3 Duration of warm up program			
5-10 minutes	60 %	3	
10-15 minutes	40 %	2	
15-20 minutes	0 %	0	
4 Strengthening and conditioning as part of the regular exercise	100%	6	
5 Frequency of Item 4			
Three times per week	66.7 %	4	
Two times per week	66.7%	1	
Once a week	16.7 %	1	
6 Focus of the warm up program on body region	83.3 %	5	
Whole body	33.3 %	2	
Neck, upper limbs and back			
7 Mode of instruction			
Active learning	83.3 %	5	
Group instruction in the classroom	83.3 %	5	
Hand-outs	50 %	3	
One on one	16.7%	1	

Consensus was reached on the content of the warm up programme, regular strengthening and conditioning exercises, frequency of the strengthening, region of the body where warm up program should be focused on and conditioning exercises and mode of instruction of injury education programmes. Consensus was reached on the content of the injury prevention programme; the participants agreed that stretching, conditioning, postural awareness and strengthening should be included. Strengthening and conditioning should be done regularly thrice a week; postural awareness and stretching are to be done before every practice session.

All six (100%) the participants agreed that warm up should be done before every practice session but consensus was not reached on the duration of the warm up, three (60%) agreed that it should be done between 5 – 10 minutes while two (40 %) agreed that it should be done between 10 – 15 minutes. However, to further reach consensus on the duration of the study a third study was conducted. All six (100 %) of the participants agreed that the conditioning and strengthening should be done as a regular exercise for instrumental musicians and consensus was reached on the frequency of the strengthening and conditioning exercise programme.

Consensus was reached on the region of the body which the programme should be focused on, five (83.3%) agreed that the programme should focus on the whole body. The opinion of the participants on the mode of instruction of the injury prevention education topics, group instruction in the classroom (83.3%) and active learning (83.3%) reached consensus.

Consensus was not reached on the content of the education topics to be included as part of the injury prevention education programme, one of the participants suggested that education on nutrition should be included in the programme. This was further considered in the third round of the study.

Third Round of Delphi study

Consensus was sought on the areas where consensus was not reached in the first and second rounds of the study; the duration of warm up exercise and the content of educational topics on injury prevention as part injury prevention education programme. Six out of the eight participants responded to the survey. Table V clearly illustrates the results of the third round of the Delphi study.

The debate over the duration of the warm up program with the inclusion of the musical warm up continued, consensus was not reached. However, the result suggests that the duration could be within 5 – 15 minutes.

Consensus was reached on the inclusion of education on nutrition to be part of the education programme as an injury preventive strategy. Therefore, the injury prevention education topics agreed upon are as follows, importance of taking breaks, proper body mechanics and posture, importance of warm up, importance of cool down, importance of stress reduction, recognition of risk factors of overuse injuries, importance of increasing practice load gradually, importance of strengthening, importance of conditioning, education on physical limitations when choosing a repertoire and nutrition.

Table V. Results of Third Round of Delphi Study (n=6)

Item	Agree	(n)	Opinion
1 Duration of warm up			
5-10 minutes	50 %	3	
10 – 15 minutes	50%	3	
2 Nutrition as part of the education topics			
Yes			
No	66.7%	4	
	33.3%	2	

Discussion

Consensus was reached in the first round of the study on the inclusion of musical warm up as part of the pre-activity warm up programme and the teaching of the correct technique of the content of the warm up programme. However, on the content of the warm up program consensus was not reached, the inclusion of aerobic exercise was not considered important by majority of the participants and it was therefore excluded from the programme. Postural awareness and frequent conditioning was suggested by the experts.

Strengthening and conditioning was agreed upon

in the second phase by the experts to be done three times per week and that postural awareness and warm up exercise should be done prior to playing. The eventual effective impact of strengthening and conditioning exercises is only seen over a period of time (12). The focus of the warm up programme with respect to the body region was agreed upon in the second phase of the study, the experts agreed that the focus of the warm up program should be on the whole body, despite evidence showing that the upper extremities, neck and back the usually the most common affected sites of PRMDs (17).

Areas of education on injury prevention strategies as described initially by Blackie, Stone, and Tiernan (18) was agreed on by the experts in the third phase of the study. The importance of breaks, proper body mechanics and posture, importance of warm up, importance of cool down, importance of stress reduction, recognition of risk factors of overuse, importance of increasing practice load gradually, importance of strengthening and conditioning, importance of identification of physical limitations when choosing a repertoire and education on nutrition were included in the injury education prevention programme. Active learning and group instruction in the classroom were agreed on by the experts to be the mode of instruction of the education programmes. However, the duration of the warm up to be done prior to playing could not be agreed up on in the three phases of the study, but the range of the warm up programme according to the results at the three phases shows that the warm up could be done preferably between 5 – 15 minutes.

Conclusion

The need for a structured warm up program with the inclusion of musical warm up as an injury prevention strategy could reduce the prevalence of PRMDs among instrumental musicians. Stretching, musical warm up and postural awareness are to be done before playing, although the role of stretching in the prevention of musculoskeletal injury among sportsmen is inconclusive. However, it should be noted that stretching exercises incorporated with other specific exercises such as strengthening and conditioning over a period of time could reduce musculoskeletal injury. The warm up program content using the Delphi study includes stretching exercises and musical warm up prior to playing while strengthening and conditioning should be done thrice a week.

Implication for further studies. The designed warm up program should be tested among musicians and this includes stretching, musical warm up and postural awareness prior to playing while strengthening and conditioning was recommended to be done thrice a week. Also, the type of stretching to be done and the number of repetition of the stretching and strengthening exercises should be determined. The overall effect of this program should be tested to determine its role in the prevention of PRMDs. Also, the influence of nutrition of the overall health of instrumental musician should be looked into.

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Impact of body mass index and gender on medial longitudinal arch drop in young healthy population

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Abstract. *Aim and scop.* The aim of this study was to compare the level of medial longitudinal arch drop, ankle joint range of motion and extension of the hallux in males and females and to correlate these values with body mass index. *Material and Method.* One hundred sixty-three medical faculty students, 74 female and 89 male, aged between 18 and 26 (20.37±1.432), were included in the study. Level of medial longitudinal arch drop, dorsiflexion and plantar flexion of the ankle and extension of the hallux were measured. Body mass index was assessed on the basis of World Health Organization (WHO) criteria. *Results*. The difference between males and females in terms of plantar flexion of the ankle (PFA), dorsiflexion of the ankle (DFA), extension of the hallux (EH) and level of navicular drop (ND), was statistically significant (pPFA=0.000, pDFA=0.003, pEH:0.043, pND=0.000). Medial arch drop was greater in individuals with a higher than normal weight in males and in total subjects **(**pmale ND= 0.007, ptotal ND= 0.001). *Conclusion*. Our determination of statistically significant differences between the sexes is important in revealing anatomical differences in terms of ankle, hallux and medial arch structures. Our conclusions show that body weight has a direct impact on the medial arch.
Key words: *Body mass index, gender, dorsiflexion, plantar flexion, navicular drop.*

Introduction

The foot is structurally and functionally complex (1). It permits body weight to be transmitted to the ground in a balanced manner. With its mechanism of absorption of the shocks to which the medial longitudinal arch is exposed, the foot-ankle complex also plays a significant role in body stabilization. It is essential to know the likely risks in order to understand the ankle and medial arch injury mechanism. While a low arch is a major risk for soft tissue injuries, a high arch is a major risk for bone injuries. A high medial arch is also a disadvantage in terms of flexibility (1).

Differences between the sexes in the foot structure have been revealed by research (2-4). Gender needs to be regarded as a risk factor and investigated in order to be able to evaluate the medial arch and ankle in structural and functional terms.

Bearing in mind that the ligaments around the joint provide joint stabilization, these ligaments being long and loose is a risk for joint stability. This may lead to sports injuries and to negative outcomes for the subsequent rehabilitation process. These structures exhibit different development in the sexes. Differences in both bone and soft tissue development reflect function.

Studies have reported differences between the sexes in terms of ankle joint range of motion, extension of the hallux (EH) and medial longitudinal arch drop. A large part of the findings show that females have looser structures (5,6). In order to establish whether this difference between the sexes is an advantage or disadvantage, the difference needs to be investigated in terms of functionality, the individual's ability to use the extremity.

In addition to leading to such metabolic diseases as hypertension, diabetes and similar disorders, body weight being greater or lower than normal is also another risk factor threatening the musculoskeletal system. Body weight is transmitted distally from the fibula and tibia to the talus by being carried along the spine. It is then transmitted from the posterior inferior direction to the calcaneus and from the anterior inferior direction to the bases of the metacarpal bones. Through weight transfer to the calcaneus and metatarsal bones, the medial longitudinal arch transfer's body weight to the ground in a balanced manner (7). Because of this relationship, mechanical changes in the foot also affect such proximal joints as the knee and hip.

If this system does not operate in a balanced manner, various deformities may appear in the foot. Pes planus is one such deformity and is more frequently seen in the elderly. Rapid weight gain and standing for long periods are two of the preparatory causes of pes planus. It is seen in children newly beginning to walk, especially in overweight subjects, and with joint laxity (8). This picture gives rise to stresses added to the muscles and undesirable outcomes involving injury to the ligaments protecting the arches. Even if the complaint in individuals with excess body weight and lower extremity musculoskeletal system problems originates from the proximal joints, the sole of the foot (medial arch) or the ankle still needs to be included in the scope of evaluation. This approach will permit greater success in the treatment and rehabilitation process.

Our study was intended to reveal functional differences in individuals' ankle, hallux and medial longitudinal arch structures and changes that may impact on functions under the effect of body weight. We thus aimed to reveal the effects of body weight on the foot and on the ankle that connects it to the proximal structures.

Material and Method

The study was performed with 163 students, 74 female and 89 male, aged 18-26 (20.37±1.432) in their first or second years at the KTU Faculty of Medicine and who agreed to take part. Participants completed written "Informed Consent Forms" and a questionnaire regarding personal data. Those performing the study read and signed the "Helsinki Declaration." The KTU Faculty of Medicine Ethical Committee approved the study. Exclusion criteria: subjects with lower extremity-related anomalies and a history of trauma, traffic accidents and surgery were excluded from analysis.

Dorsiflexion of the ankle (DFA), plantar flexion of the ankle (PFA) and EH were measured using a universal goniometer, and medial arch drop using the "navicular drop test" on both sides for all individuals in the study.

Outcome Measurements. These were completed under four measurements and headings: 1.calculation of body mass index (BMI); 2. dorsiflexion of the ankle (DFA) and plantar flexion of the ankle (PFA); 3. extension of the hallux (EH); 4. level of navicular drop (ND) (navicular drop test).

Calculation of BMI was calculated using the formula "[Body weight (kg) /Height^2 (m^2)]". Individuals' height in the anatomic position was determined using a stadiometer (9). Subjects' body weights were measured using digital scales sensitive to 10 g. Individuals were classified on the basis of the WHO BMI classification into underweight (UW), normalweight (NW) and overweight (OW) groups (10).

Measurements of Dorsiflexion of the Ankle (DFA) and Plantar Flexion of the Ankle (PFA) were performed in a seated position with the feet not touching the ground and with the hip and knee joints flexed at 90˚. Active dorsiflexion and plantar flexion of the ankle were requested. Neutral ankle position was taken as a 90˚ perpendicular angle between the 5th metatarsal and the os fibularis. The point on the joint indicated by the center of the goniometer was marked as the pivot point. This point was the malleolus lateralis for the ankle. The fixed arm of the universal goniometer was maintained parallel to the long axis of the fibula while the mobile arm was positioned so as to follow the long axis of the 5th metatarsal. Before measurement the participants were asked to move their ankles a few times in the desired directions. No pedal inversion or eversion was permitted during measurement. The value at which movement was completed was recorded. Measurements were taken three times and the values obtained recorded. The same procedure was then performed for the other ankle (11).

Extension of Hallux (EH) measurement was performed with the subject standing upright (with body weight transferred to the foot to be measured) on a hard floor. The subject was permitted to hold onto a bar at the side for the purpose of maintaining balance. The medial of the basis of the first metatarsal was taken as the pivot point. Measurement was performed with the fixed arm parallel to the ground and the mobile arm following the hallux. Subjects were asked to bring the hallux to full extension. Measurements were taken once they had fully grasped this movement. The researcher stood medially to the hallux to be measured. The value at the final point of the hallux extension movement was measured. Values taken three times for each hallux were recorded (12).

Arch drop measurement was performed using the "navicular drop test," under two conditions, with body weight on or off the foot to be measured (13-15). During measurement in which body weight was not transferred, the subject was seated in a chair of adjustable height. Both knees were arranged at 90^0 flexion with the ankles in the neutral position, and with the sole of the foot touching the ground.

The most protruding part of the navicular bone was then determined. The points identified were marked with a line running parallel to the ground. This line was determined as the apex of the medial arch. The distance between the marked line and the ground was measured with a digital compass and arch height values recorded in millimeters. In measurements in which weight was transferred, subjects stood on one foot on a flat and hard surface, holding onto a bar for balance. Arch height for both feet was measured in this position using digital compasses. These measurements were performed three times for each foot. Valued were recorded as millimeters. With these measurements we determined the height of the medial arch when bearing and not bearing body weight.

Statistical analysis. Statistical analysis of the values obtained by measurement was performed using SPSS 13.0. The Independent Simple Test was used for normally distributed measurements in the analysis of measurement values between the sexes. ANOVA and post-hoc Bonferroni were used for statistical analysis of the BMI groups (1,16).

Results

Body Mass Index-Related Results. There was no difference in terms of measurements between female BMI groups. (Table 3). The difference between BMI groups in terms of male mean ND was statistically significant (p=0.007) (Table 1). When male BMI groups were compared for ND in terms of paired relations, the greatest difference was that between NW and OW (p=0.019) (Table 2). On the basis of this result, body weight has a significant effect on arch drop.

In terms of mean ND in total male and female subjects, the difference between BMI was statistically significant (p=0.000) (Table 1). The greatest difference in terms of ND between the BMI groups in all male and female subjects was that between UW and OW (p=0.000) (Table 2).

Gender-Related Results. The difference between male and female mean PFA results was statistically significant (p=0.000), as was that between male and female mean DFA results (p=0.003) and male and female mean EH findings (p=0.043). The difference between mean male and female ND results was also statistically significant (p=0.000) (Table 3).

The difference between male and female individuals' mean PFAs on the right side was again statistically significant (p=0.000). The differences between male and female individuals' mean DFA (p=0.001) and ND results on the right side were also statistically significant (p=0.001). In terms of EH measurement on the right side, there was no difference between the sexes (p=0.056) (Table 4).

On the left side, the difference between male and female individuals' mean PFAs was statistically significant (p=0.000), as were those for male and female individuals' mean DFAs (p=0.022) and NDs (p=0.002). There was no difference between the sexes in terms of EH measurement on the left side (p=0.082) (Table 4).

Table I. Statistical comparison of the measurements (PF, DP, EH, ND) between the BMI groups*
*Total n= 163 (74 female, 89 male) p values<0.05. PFA: Plantar flexion of the ankle; DFA: Dorsiflexion of the ankle; EH: Extension of the hallux; ND : Navicular drop; UW: Under Weight; NW : Normal Weight; OW : Over Weight.

SEX	Measurement	BMI Groups						
			UW		NW		OW	
		N	Mean± SD	N	Mean± SD	N	Mean± SD	P
FEMALE	PFA	16	60.41±4.55	48	61.53±6.92	10	61.62±10.38	0.850
	DFA	16	18.73±5.31	48	19.21±7.17	10	16.67±5.35	0.542
	EH	16	24.57±6.70	48	25.09±6.95	10	25.97±8.53	0.889
	ND	16	5.04±3.44	48	5.74±2.51	10	7.06±2.06	0.181
MALE	PFA	4	56.88± 3.83	55	56.63±6.19	30	58.44±7.28	0.474
	DFA	4	19.38±2.08	55	16.13±6.01	30	14.95±5.38	0.307
	EH	4	32.33±9.19	55	21.72±8.37	30	22.57±10.39	0.086
	ND	4	5.38±1.78	55	6.89±2.79	30	8.51±2.11	**0.007**
TOTAL	PFA	20	59.70±4.55	103	58.91±6.96	40	59.23±8.14	0.891
	DFA	20	18.86±4.80	103	17.57±6.72	40	15.38±5.36	0.077
	EH	20	26.12±7.68	103	23.29±7.89	40	23.41±9.96	0.380
	ND	20	5.11±3.14	103	6.35±2.71	40	8.14±2.17	**0.001**

Table II. Binary statistical comparison of the measurements (PF, DP, EH, ND) between the BMI groups*

Sex	Measurement	BMI	P
Female	ND	UW-NW	1.000
		UW-OW	0.198
		NW-OW	0.486
Male	ND	UW-NW	0.767
		UW-OW	0.070
		NW-OW	**0.019**
Total	ND	UW-NW	0.167
		UW-OW	**0.001**
		NW-OW	**0.001**

*Total n= 163 (74 female, 89 male) p values<0.05

Table III. Statistical comparison of the total measurements on both sides between males and females*

Measurement	Female [Left+Right]/2 Mean± SD	Male [Left+Right]/2 Mean± SD	P
PFA	61.30±6.97	57.25±6.50	**0.000**
DFA	18.77±6.57	15.88±5.72	**0.003**
EH	25.10±7.04	22.48±9.29	**0.043**
ND	5.77±2.71	7.36±2.66	**0.000**

*Total n 163 (74 female, 89 male); all p values < 0,05

Table IV. Statistical diferences of the measurements between males and females at right and left sides*

Measurement	Female		Male		P
	Right Mean±	Left Mean ±	Right Mean±	Left Mean ±	
PFA	61.31±7.29		57.30±6.86		**0.000**
		61.28±7.18		57.21±7.18	**0.000**
DFA	18.64±6.70		15.24±6.03		**0.001**
		18.89±7.07		16.52±6.08	**0.022**
EH	25.99±8.64		23.09±10.25		0.056
		24.20±7.21		21.87±9.39	0.082
ND	6.09±2.99		7.66±3.08		**0.001**
		5.44±3.35		7.07±3.35	**0.002**

*Total n= 163 (74 female, 89 male) p values<0.05

Discussion

Considering the entire body, females generally have greater ligament laxity than males (7). This state of affairs in the foot is in agreement with the findings from our study. Lunsford et al. (17) determined significantly greater degrees of plantar flexion in females compared to males, again in agreement with our study.

The PF and DF values in our study were also higher in female individuals compared to males on both sides. In contrast to our results and those of Brenda et al., Darin et al. (7) reported no difference between the sexes in young individuals in terms of joint movements.

Studies show that there is a difference between the sexes in terms of muscle power and that males are stronger than females (18, 19). Greater strength in the muscles surrounding the ankle and the medial longitudinal arch may be regarded as a flexibility-reducing factor.

The ankle transmits the weight of the body to the foot via the tendons. As points of connection between the muscle and bone tissue, these are stronger and have a greater volume in males. Greater strength causes the tendons and the connective tissue around the joint to become stiffer (harder). This explains why we determined lower ankle joint movement in males compared to females.

Padua et al. (5) determined a difference in stiffness between the sexes. In another study, Padua et al. (6) compared leg stiffness in males and females. They determined lower leg stiffness in females compared to males, but no difference between the sexes in terms of range of ankle and knee joint movement. In our study, mean arch drop levels were greater in males compared to females. We associate the difference in the level of arch drop with range of joint movement and anatomical differences between the sexes. The greater flexibility in females suggests that the level of arch drop should also be higher. Contrary to expectation, the level of drop in our results was greater in males.

Micle et al. (20) hought that the reason for the more frequent observation of pes planus in boys compared to girls in the pre-school period may be the differences in anatomical structures between the sexes. They conducted a study with pre-school children intended to reveal the relationship between gender and the sole of the foot. They determined a higher level of drop in males in the pre-school period, suggesting that the medial longitudinal arch develops later in boys compared to girls in the pre-school period. Micle et al. (20) looked at the development of the individual's medial longitudinal arch from the newborn period onward and suggested that there is a lower level of drop in girls in the pre-school period. Otuska et al. (21) determined greater arch drop in old age in women compared to men. The age range of the individuals in our study was 18-26. The greater medial arch drop in males, on both right and left, compared to females was compatible with a study by Micle et al. (20), despite the age difference. In another study on the effect of gender on arch drop, Walter et al. (22) found that the level of drop in girls playing football and basketball was no different to that in males. We think that individuals engaging in sport may account for the insignificant nature of the difference.

Otsuka et al. (21) investigated the level of arch drop in individuals of advanced age and determined that pes planus is a deformity bringing with it pain and tiredness and seen more frequently among females in this age group.

As expected, our results show that individuals with greater body weight have a greater level of arch drop. We think that elevated body weight is one reason for greater collapse of the medial longitudinal arch, a load-bearing structure, and is therefore involved in the etiology of pes planus. There was a positive correlation in our study between excess body weight and level of arch drop in both lower extremities, irrespective of gender. In other words, the level of arch drop was greater in fatter individuals. In their study analyzing navicular drop levels among 19 overweight and 19 normal weight children Karen et al. (23) observed higher levels of pes planus among fatter children. They suggested that excessive drop of the plantar arch may lead to various changes in anatomical structures and that these changes may represent a risk in terms of potential pes planus when the child reaches adulthood. That study supports our findings in terms of the effect of body weight on the medial longitudinal arch.

Ferri et al. (24) used CT scanning in a study of 48 subjects, 18 with a normal arch and 30 with painful flexible pes planus, and their results are compatible with ours. They analyzed the level of arch drop with weight transmitted and not transmitted and determined that the subjects with pes planus also had greater body weight. Another study analyzing BMI and pes planus was performed by Fuhrmann et al. (25) The results of that study, which regarded obesity as a factor impairing foot stability support, in respect of the group with pes planus deformity having higher BMIs, support those of our study.

Otsuka et al., (21) in a study of individuals aged over 60, and Bordin et al. (26) in a study of 243 middle school students, also determined greater pes planus in obese individuals. McPoil et al. (14) investigated the effect of body weight on level of navicular drop in 275 participants. Measurements were taken with 50% of body weight transferred to the foot and with no weight transfer. The mean difference between the two states was 10 mm. They also analyzed the same subjects using X-ray. No difference was determined between measurements in the two techniques. They regarded the "navicular drop test" as a practical technique that can be used in clinical practice. The "navicular drop test" used in our study is reliable and easily applied in practice.

Ulunay Kanatlı et al. (26) investigated forms of dynamic metatarsal head pressure distribution in healthy subjects. In the pre-swing phase, they determined a significant correlation between load values on the sole of the foot and BMI. They observed that the load on the first metatarsal was greater in individuals with higher body weight. In terms of load distribution on the sole of the foot, the first metatarsal is known to be exposed to greater load than the other toes. Increases in body weight inevitably increase this load on the medial arch.

Actively measured extension of the hallux was not correlated with body weight in our study.

There was no difference in terms of measurements between the sexes in overweight individuals. In the light of our results we therefore conclude that excess weight is a more effective factor than gender in foot instability.

Conclusion

Our determination of statistically significant differences between the sexes is important in revealing anatomical differences in terms of ankle, hallux and medial arch structures. Our conclusions show that body weight has a direct impact on the medial arch.

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Biomechanical differences between jump topspin serve and jump float serve of elite Greek female volleyball players

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Abstract. *Aim and scope.* The purpose of this study was to describe the biomechanical differences between jump topspin serve and jump float serve of elite young female Greek volleyball athletes. *Material and methods.* 12 international players volunteered and performed randomly three jump topspin and three jump float serves. MNTCS video cameras filming at 100Hz recorded the players during the serves. *Results*. Jump topspin serve presented higher values compared to jump float serve on ball velocity, horizontal COM displacement, jump height, spike height and COM velocities during take-off phase. As well as that, players during jump topspin serve revealed higher values in all examined linear joint velocities of upper limbs. Finally, a proximal to distal pattern was observed in both serves regarding velocity of upper body joints. *Conclusions.* Jumping topspin serve, though risky, can generate a more difficult scenario for defense. Results from this study could be used by professional coaches or by athletes themselves to better train these two types of serves.
Key words: *biomechanics, volleyball jump serve, topspin serve*.

Introduction

One of the basic skills in volleyball is the serve and particularly in its more powerful form the jump serving. Jump serving is similar to another basic skill of volleyball, that of spike, and consists of the throwing of the ball into the air, running and jumping to achieve greater power output when smashing the ball towards opponent's court. These skills require continuous overhand movements which in turn may induce overload and injury of upper extremities (1).

In this point, proper mechanics may enable an athlete to achieve maximum performance with minimum risk of overload or finally injury (2).

There has been a considerable amount of attention in biomechanical researchers concerning volleyball serve (3-5) but little regarding attacking serves (jump topspin/jump float serve) in elite athletes which in fact attacking serves can affect the total match (6,7).

Therefore, the purpose of this study was to describe the biomechanical differences between jump topspin serve and jump float serve of elite young female Greek volleyball athletes and to provide some biomechanical factors involved in these two types of jump serves.

Material and Method

Twelve international female players, 17.8±1.4 years old, from Greek Youth Team of 176±4.5cm height and 70.1±4kg mass, were filmed during competition using two AG188, NTCS video cameras filming at 100Hz. Participants anthropometrics are listed below in table I as well.

All participants performed jump topspin serves and float serves as well. Successful serves were recorded, and their approximate impact point on opposite court was noted and only one successful attempt for each subject was chosen for further analysis. The two cameras were placed on each end of service line in a field size resolution of 36x240, in order to record athletes' serves.

Finally, a calibration board (60x60cm) was videotaped along the serve line by 1 m apart in for calibration purposes.

Participants' parents signed informed consent form before executing any task.

14 body landmarks (shoulders, elbows, wrists, fingers, and ball) were digitized and analyzed with the Kwon 3D motion analysis system. Digitizing includes approximately period before last heel and after ball contact. A 14-segment model was used for subject digitization, with

standardized anthropometric measurements obtained previously (5).The objects pace coordinates and computed angles were then smoothed and differentiated using the generalized cross-validated quintic splines algorithm reported by Woltring (8). Data were tabulated and kinetograms and graphical output plotted.

The segment COM, and body COM were calculated. The x and y COM of 2D data were calculated as well. The COM jump height was defined as the distance between the COM at the moment of take-off to the highest point that athlete reached. The spike height was defined as the height of impact ball to the court. The COM horizontal distance was defined as the COM at take-off to COM at the moment of contact with the ball. Differences between upper limb linear kinematics, COM velocities and vertical displacement between jump topspin serve and jump float serve were analyzed.

An analysis of variance (ANOVA) was performed to test, when possible, the effect of jump serve (topspin or float) on each dependent variable. The significance level was set at 0.05 for all tests performed.

Statistical analysis was performed using Statistical Package for Social Sciences (SPSS 17 Inc. Chicago, IL, USA).

Table I. Anthropometrical characteristics and main variables of participants

Variables	**Mean ± SD**
Age (years)	17.8± 1.48
Height (cm)	176.6± 4.48
Weight (kg)	70.1± 4.93
Volleyball experience (years)	8.1± 2.66
Player's position	Attackers

Results

The jump topspin serve revealed higher values than jump float serve on ball velocity, jump height and spike height ($p<0.05$). Jump height of COM during topspin serve was higher compared to float serve ($p<0.01$). Ball velocity reaches the value of 21m/s during topspin serve and this was statistically significant than float serve ($p<0.05$). In addition to this, spike heights of players during topspin and float jump serves were 259.3 and 248.8 cm respectively ($p<0.05$).

The mean horizontal displacement of COM from the moment of take-off till the contact of the ball was 80.6 cm and 41.8 cm respectively for jump topspin and jump float serve ($p<0.01$). Finally, velocities at take-off were higher in jump topspin serve as expected compared to float ones ($p<0.05$). All the above mentioned results are presented on table II below.

Regarding upper extremities joint linear velocities during the two types of serves, the following were found. Jump topspin serves revealed higher values of linear velocities in all examined joints compared to float serve (shoulder, elbow, wrist and finger). All the above mentioned results are presented on table III below.

Table II. Selected variables of jump topspin serve and jump float serve

Variable	**Float Serve** (Mean±SD)	**Topspin Serve** (Mean±SD)	
Ball velocity (m/s)	17.55±0.85	20.93±1.78	*
COM_X velocity (m/s)	2.00±0.26	2.33±0.31	*
COM_y velocity (m/s)	2.55±0.14	2.85±0.39	*
COM_X displacement (cm)	41.83±2.32	80.67±4.84	***
Spike height (cm)	248.83±13.29	259.33±22.97	*
COM jump height (cm)	27.67±6.83	44.33±2.88	**

***, **, ***:** *significant difference between the two groups (p<0.05, p<0.01, and p<0.001, respectively)*

Table III. Linear velocities of selected upper limb joints in jump topspin serve and jump float serve

Variable	**Float Serve** (Mean±SD)	**Topspin Serve** (Mean±SD)	
Finger velocity (m/s)	13.35±0.53	14.75±0.44	*
Wrist velocity (m/s)	10.88±0.8	11.82±0.39	*
Elbow velocity (m/s)	5.12±0.31	6.08±0.26	*
Shoulder velocity (m/s)	2.95±0.22	3.42±0.27	*
***, **, ***:** *significant difference between the two groups (p<0.05, p<0.01, and p<0.001, respectively)*			

Discussion

The purpose of this study was to examine the biomechanical differences between the jump topspin serve and the jump float serve in elite young international Greek players.

Ball velocity reaches the value of 21m/s during topspin serve and this value is relatively low compared to relevant studies but in elite men population (5). As expected, jump height during topspin serve was higher compared to float serve. This difference is in agreement with recent research (9) which determined that jump spin servers jumped higher off the ground in contrast to jump float servers and this probable occurred due to the higher toss generated during topspin serve. Spike heights of players during topspin serves were higher and these findings may predispose that the serves of these athletes were offensive enough taking into account that the net height is 243cm. The mean horizontal displacement of COM from the moment of take-off till the contact of the ball was 80.6 cm and 41.8 cm respectively for jump topspin and jump float serve (p<0.01). This in fact reveals that athletes during topspin serve jumped higher and forward.

Though the movement pattern and sequence seem similar in these two types of serves, there are important differences on a kinematic level. During the serve, the energy was transferred from the lower extremities to upper extremities and then finally to the ball. The observed increment in velocity from proximal to distal joints represents in fact the so-called principle of kinematic chain in every similar movement of striking (7,3,10,5).

Limitations of this study include the relatively small sample size (n=12), single sex (female) and single skill level. Thus, the findings may not apply to all volleyball players. Another limitation was the use of surface markers for quantifying joint motion. However, to limit variability in marker placement, a single investigator attached all the markers on all the athletes. The effect of surface marker variability was further reduced by using a repeated-measures design to compare the skills within each participant. Because markers were not moved for anyone during the trials, the same marker locations were used for the joint biomechanics of all compared skills.

Conclusions

The purpose of this study was to describe the biomechanical characteristics of the jump topspin and jump float serve performed by elite female international volleyball players. Jump topspin serves revealed greater values than the jump float serve on ball velocity, body CM velocities at takeoff, jump height, spike height, and horizontal body CM displacement. It is suggested that these biomechanical differentiation between the two types of jump serve should be addressed from coaches and professional assistants to athletes when designing training programs related with this valuable weapon that of attacking serve in volleyball.

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A comparative study on static and dynamic balance in male collegiate soccer and basketball athletes

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Abstract. *Objective.* Performance of athletes from different sports on balance tests is not well understood. Prescription of balance exercises to athletes in different sports may be an important to recognize performance variations. Thus current study was compared static and dynamic balance among soccer and basketball collegiate athletes. *Material and Method.* A sample of 40 male volunteers from collegiate soccer and basketball athletes with mean age of 19.2±1.42years were participated in the current study. Subjects were divided into two respective groups of basketball and soccer (n =20). Study outcomes were assessed the static and dynamic balances by Balance Error Scoring System (BESS) and Star Excursion Balance Test (SEBT) respectively in both groups. *Results.* Results indicated that both basketball and soccer athletes had similar static balance measure on BESS irrespective of dominant or non-dominant extremity. SEBT comparisons revealed that statistically significant difference were found between two groups of athletes for dominant extremity in all the three reach directions. Results indicated that increased reach distance of soccer athletes on SEBT showed better dynamic balance ability than basketball athletes. *Conclusions.* Basketball and soccer players did not differ in terms of static balance. In contrast, basketball players displayed inferior dynamic balance compared with soccer players. With this insight, athletic trainers may prescribe balance exercises more effectively to athletes from basketball and soccer players.
Key Words: *proprioception, postural control, motor learning, attention.*

Introduction

Balance during sports activities requires proper neuromuscular control, which is a unique integration of inputs from the periphery into the central nervous system and back, with the aim of maintaining the posture in non-constant, external environment. This occurs unconsciously and skeletal muscles surrounding a joint are automatically activated in response to sensory stimuli (1). To maintain upright stance, the central and peripheral components of the nervous system are constantly interacting to control body alignment and the center of gravity over the base of support where peripheral components in balance include the somatosensory, visual, and vestibular systems and via central nervous system these peripheral inputs selects the most appropriate muscular responses to control body position and posture over the base of support (2).

Athletic trainers often prescribe exercises in an attempt to enhance an athlete's postural control or balance and perhaps reduce the risk of injury. Unipedal balance tasks on progressively challenging surfaces (firm floor to ankle disc) are examples of exercises that have improved the balance of athletes after ankle sprains (3). Differences in ankle and knee proprioception between trained athletes and matched controls suggest that sport participation challenges the sensorimotor systems and may enhance balance (4). Furthermore, balance ability is essential for top athletes, in order to reach peak performance in sport competitions and balance is also a very important factor for athlete talent identification since only in dynamic balance during human movement, can muscle create adequate power and strength.

Sport training enhances the ability to use somatosensory information, which improves postural capabilities. Postural changes are different according to the sport practiced. For example, judo training leads to greater importance being placed on somatosensory information, whereas dance training results in more attention to visual information. Each sport develops specific postural adaptations that are not transferable to the usual upright postures (5). Some evidence in the literature suggests that superior balance among experienced athletes is largely the result of repetitive training experiences that influence motor responses and not greater sensitivity of the vestibular system (6). Other argue that superior balance is the result of training experiences that influence a person's ability to attend to relevant proprioceptive and visual cues (7**).** Although experts may not agree on the mechanism, research suggests that changes in both sensory and motor systems influence balance performance (8).

Basketball is becoming increasingly popular in many countries and is played worldwide by more than 450million people. Because basketball is a contact pivot sport, its associated injury rate is high (9). Soccer is the most popular team sport in the world with nearly 200 million players (10). Soccer incorporates periods of high-intensity exercise interspersed with periods of lower-intensity exercise. Basketball is an intermittent sport incorporating quick and repeated changes in the direction of movement. It has been demonstrated that during soccer and basketball matches the players perform several jumps, tackles, and turns, changing place constantly (11). Basketball players often perform upper extremity passing, shooting, and dribbling skills while wearing shoes on flat, stiff surfaces. Their skills require great joint accelerations from jump landings and cutting maneuvers. Soccer players often perform lower extremity passing, shooting, and dribbling skills while wearing cleated or non-cleated shoes on variable turf conditions. Each sport likely requires different levels of sensorimotor processes to perform skills and protect the neuromuscular system from injury.

The skill requirements and environmental demands of these aforementioned sports likely pose different challenges to the sensorimotor systems that cumulatively may influence the balance abilities of trained athletes (12).

Functional-performance tests are dynamic measures used to assess general lower body function because they combine multiple components, such as muscular strength, neuromuscular coordination, and joint stability, which could be affected after joint injury. Measurement of postural control is an important tool in the assessment of pediatric, geriatric, and athletic populations for establishing levels of neuromuscular function for the purposes of injury prevention and rehabilitation (13**).**

To our knowledge, there is dearth of studies comparing balance abilities among athletes competing in different sports. Therefore, our purpose was to compare static and dynamic balance among collegiate athletes currently competing or training in soccer and basketball.

Material and Method

A sample of 40 male volunteers with mean age of 19.2±1.42 years from collegiate soccer and basketball athletes who met the inclusion criteria such as age between 17-25 years, competing in single sport for the previous 1-3 years and not involved in any form of balance training program outside of their typical sport training were participated in the current study. Subjects were excluded from the study that had a lower extremity injury, vestibular problems, visual problems, or a concussion in the 12 weeks before the study and limb length discrepancy. Subjects were divided into two respective groups of basketball and soccer (n=20). Study outcomes were assessed by static and dynamic balances in both groups.

Static balance was assessed by using the Balance Error Scoring System (BESS) (14). The unstable surface consisted of closed-cell foam and stable surface was floor. The procedures for the BESS test involved 3 stance positions each on the stable and unstable surfaces for the dominant and non-dominant limbs. The 3 stance positions are double-leg stance with feet together, single-leg stance on test limb with contralateral knee in approximately 90° of flexion, and tandem stance with the foot of the test limb in line and anterior to the foot of the contralateral limb (ie, the heel of the test foot touching the toes of the back foot). Participants were instructed to stand quietly and motionless in the stance position, keeping the eyes closed and hands on the iliac crests. Upon losing their balance, they were to make any necessary adjustments and return to the initial testing position within 5 seconds. Verbal instructions and a demonstration of the BESS were given to each participant before testing began. Participants were scored based upon the errors recorded during each

of the 6 balance tasks. Each position is held with eyes closed and hands on hips for 20 seconds in duration, and scoring is determined by recording of errors. Errors included (1) opening eyes; (2) lifting hands from hip; (3) touchdown of non-stance foot; (4) step, hop, or other movement of the stance foot or feet; (5) lifting forefoot or heel; (6) moving hip into more than 30° of flexion or abduction; and (7) remaining out of position for longer than 5 seconds.

Dynamic balance was assessed using the Star Excursion Balance Test (SEBT) (13). The testing grid consisted of 8 lines, each 120 cm in length extending from a common point at 45° angle increments and is created using standard white athletic tape placed on a firm surface. The middle of the grid is marked with a small dot that athletes were asked to center the stance foot over during testing. The grid is marked at 1-cm increments from the center outward to facilitate scoring during testing. The SEBT protocol requires participants to maintain a stable single-leg stance with each leg and to reach for maximal distance with the other leg. The orders of reach direction are randomly selected before testing, and a 5-second rest with a 2-footed stance is required between reach attempts. Three trials were performed for each limb, with a 120-second rest period between trials. Each participant performed 4 practice trials before getting evaluated for the reach distance in 3 of the 8 directions (anterior, posterior, lateral) and placed his or her left foot on the center of 0-180 degree line. Then, participants reached their toes as far as possible to the directions of 0, 90, and 180 degree lines while maintaining balance**.** Participants performed the same sequence with their right foot. All participants followed the same procedure. Each participant performed 3 trials for each foot and their best reaches were recorded manually. Visual cues, such as objects on the floor and people not involved in the study, were removed from the testing area to help reduce visual and auditory influences. No encouragement or further instructions were given to the participants throughout testing. Reach distance was marked with chalk on the floor immediately next to the athletic tape that corresponded to the site of touchdown. The distance from the center of the grid to the point of touchdown was measured with a tape measure, the value was recorded to the nearest millimeter, and the chalk mark was removed after each reach to reduce visual cues.

All scoring was performed by the same researcher.

The error scores from the BESS test were summed for each limb, and the distance scores (cm) for each direction of the SEBT grid were averaged over the 3 trials and normalized to leg length (reach distance/leg length x 100 = percentage of leg length).

Results

Data analysis was done by using the software package SPSS 17.0. The mean and standard deviation of all the variables were analyzed. Simple t-test was used to analyze the difference between basketball and soccer groups on static and dynamic balance (Table I).

Comparisons revealed that BESS scores were statistically insignificant for dominant legs between basketball (12.25±1.77) and soccer (13.05±2.32) groups and non-dominant legs also showed similar insignificant result between basketball (12.80± 2.64) soccer (13.15±2.45) groups respectively. Results indicated that both groups of athletes had similar static balance measure on BESS irrespective of dominant or non-dominant extremity (Fig. 1).

The SEBT comparisons revealed that statistically significant difference ($p< .01$) were found between two groups of athletes for dominant extremity in all the three reach directions. Anterior reach distance for basketball group (98.41±1.95) was found to be less than for soccer group (100.39 ± 1.34). Posterior reach distance for basketball group (103.71±1.31) was found to be less than for soccer group (106.55±1.47). Similarly, the lateral reach distance for basketball group (87.47±1.36) was found to be less than for soccer group (90.12±1.31). Results indicated that increased reach distance of soccer athletes on SEBT showed better dynamic balance ability than basketball athletes (Fig. 2).

Comparisons revealed that statistically significant difference ($p<.01$) were found between two groups of athletes for non-dominant extremity in all the three reach directions. Anterior reach distance for basketball group (98.31±2.02) was found to be less than for soccer group (100.60±1.43). Posterior reach distance for basketball group 103.60±1.37) was found to be less than for soccer group (106.75±1.73). Similarly, the lateral reach distance for basketball group (87.85±1.27) was found to be less than for soccer group (90.12±1.44). Results indicated that increased reach distance of soccer athletes on SEBT showed better dynamic balance ability than basketball athletes (Fig. 3).

Table I. Comparisons of BESS and SEBT scores between groups

Variables	Extremity	Components	Basketball Group (n=20) Mean ± SD	Soccer Group (n=20) Mean ± SD	t-value
BESS	Dominant		12.25±1.77	13.05±2.32	1.22^{NS}
	Non-dominant		12.80±2.64	13.15±2.45	.43^{NS}
SEBT	Dominant	Anterior Reach	98.41±1.95	100.39±1.34	3.77**
		Posterior Reach	103.71±1.31	106.55±1.47	6.44**
		Lateral Reach	87.47±1.36	90.12±1.31	5.04**
	Non-dominant	Anterior Reach	98.31±2.02	100.60±1.43	4.13**
		Posterior Reach	103.60±1.37	106.75±1.73	6.37**
		Lateral Reach	87.85±1.27	90.12±1.44	5.28**
^{NS}non-significant; **significant at .01 level					

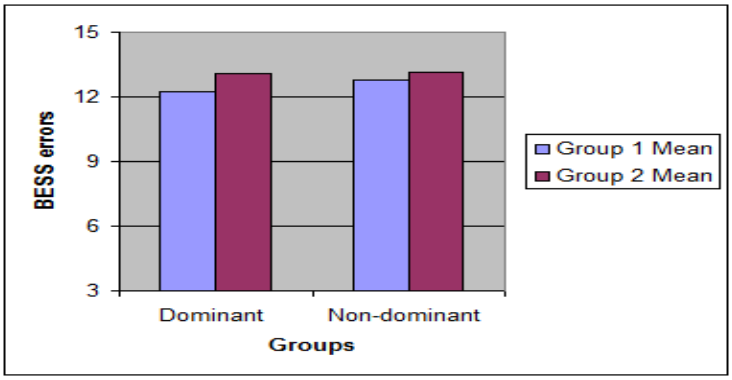

Figure 1. Comparison of BESS

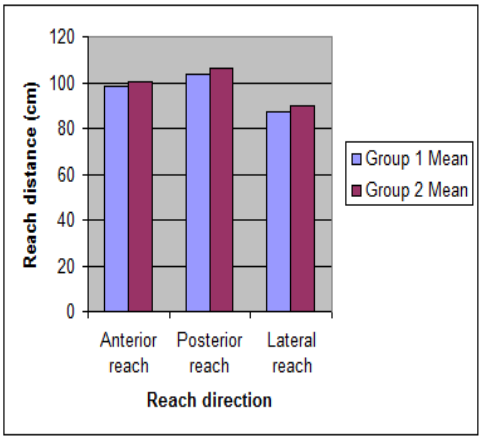

Figure 2. Comparison of BESS (Dominant Leg)

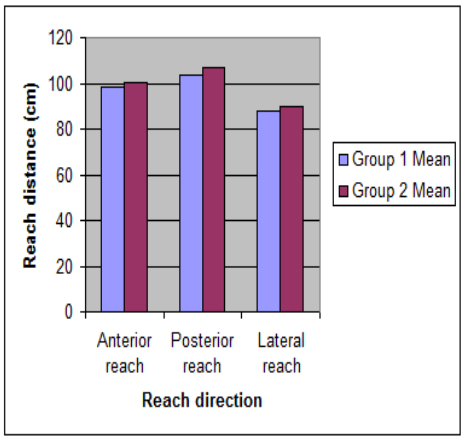

Figure 3. Comparison of SEBT (Non-Dominant Leg)

Discussion

To our knowledge, studies comparing balance abilities among athletes competing in different sports did not exist. Therefore, our purpose was to compare static and dynamic balance among collegiate athletes currently competing or training in soccer and basketball. What seems to be lacking from previous researches is an appreciation of how athletes from different sports perform on balance tests.

It would seem logical that a sport like soccer and basketball which involves a great deal of starting, stopping, changing of direction, and contact would benefit measuring an athlete's ability to maintain balance while moving.

Balance was found to be a risk factor for many musculoskeletal injuries. Significant reductions in ankle sprains were seen in athletes using balance training programs that had both preseason and

in-season components and were performed in a team setting as part of the regular training or practice session (15). An altered sense of balance will heighten functional ankle instability because of increased movement at the body's periphery, away from the center of gravity (16).

Dynamic stability as it relates to the maintenance of equilibrium while moving, would logically be expected to have an effect on a playing ability, especially for sports in which athletes are moving, turning, twisting, jumping, stopping, cutting, accelerating, and decelerating[9]. Soccer incorporates periods of high-intensity exercise interspersed with periods of lower-intensity exercise. Basketball is an intermittent sport incorporating quick and repeated changes in the direction of movement. It has been demonstrated that during soccer and basketball matches the players perform several jumps, tackles, and turns, changing place constantly (11). Hence, the sports represented in our study (soccer, basketball) both require similar movements (running, jumping, cutting, deceleration, and acceleration) to adequately perform the chosen activity.

The BESS was developed to provide clinicians with an inexpensive and practical tool for the assessment of postural stability (17). Hence we preferred to use these reliable, inexpensive, quick, portable tools for assessing static and dynamic balance. The recommended SEBT protocol can be time-consuming for clinicians to administer because it requires 9 trials (6 practice, 3 test trials) for each of the 8 directions. For this reason, research was undertaken to determine if the SEBT administration can be simplified without diminishing the validity of the test and found that there was functional redundancy across the 8 reach directions and led to the recommendation that the number of no of practice trials could be reduced from 6 to 4 and reach directions administered could be decreased from 8 to 3 without affecting its validity (18).

Within our study, the statistical differences observed among sports may, in part, be related to the unique sensorimotor challenges imposed by each sport. The skill requirements and environmental demands of these aforementioned sports likely pose different challenges to the sensorimotor systems that cumulatively may influence the balance and performance abilities of trained athletes (12). Others argue that superior balance and performance is the result of training experiences that influence a person's ability to attend to relevant proprioceptive and visual cues. With training the individual passes from the cognitive to the associative phase of learning and thence after months or perhaps years to the autonomous learning phase wherein the adjustments become automatic. One benefit is that the individual then may require reduced attention to perform the skill (19).

An athlete can have differences in their two balance components as a study previously reported that performance in the static balance test was not reflective of performance in the dynamic balance test, hence suggested that attempting to infer dynamic balance ability based on static balance ability should be avoided (16). Because static balance scores were not significantly different between soccer and basketball players, some sensorimotor challenges may be common in these two sports, or it could be the reason that the BESS was not sensitive enough to pick up the differences.

The data obtained from a previous study that found H/Q ratio did not differ among the different divisions of basketball and soccer players. Based on this, the current study concluded that the subject's body weight have a decisive effect on the production of peak torque values of quadriceps and hamstring muscles in basketball and soccer players (20). Basketball players are significantly taller and heavier than soccer players (11) and it is known that body composition plays a important role on the physical performance since extra body fat acts as a non beneficial factor in activities like soccer and basketball (21).

Basketball players rarely balance motionless on one leg and often attend to ball and player position cues. With respect to dynamic balance, soccer players often require unipedal posture for reaching movements outside their base of support during passing, receiving, and shooting (5) and also soccer players encounter with more uneven or unstable surface during foot placement in competitive sports as compared to basketball players. It was seen that different conditions and interventions may influence dynamic balance but not static balance. This indicates that there may not be a strong relationship between static and dynamic balance parameters (16). Soccer calls on and stimulates sensory receptors because of frequent changes in direction and hence athletes develop more strategies for maintaining balance in more unstable situations during specific activity of carrying the ball (22). These factors could explain why their dynamic balance was better than basketball players although no direct evidence supports this contention.

Intuitively, balance training reduces the risk of some musculoskeletal injuries, such as ankle sprains, especially if one or more balance components (eg, proprioception and joint ROM) are not optimal at the start. The literature seems to support this contention in that athletes in different sports displayed fewer ankle sprains and other musculoskeletal injuries than control subjects after static and dynamic balance training (23). The combination of rehabilitative and proprioceptive exercises has been shown to decrease the chance of recurrent ankle sprains as well as reduce the chance of re-injury in a functionally stable ankle. This suggests that proprioceptive deficiencies can be improved through a variety of balance exercises. Balance training can be used prophylactically or after an acute ankle sprain in an effort to reduce future ankle sprains. Incorporating balance training exercises, such as balance board exercises, into pre-season and in-season conditioning programs for athletes in these sports could improve their sporting skills and decrease their risk of sustaining injuries.

In addition to knowing which balance training programs are effective, athletic trainers would benefit from knowing which athletes require more balance training to reduce musculoskeletal injuries. Because we observed inferior balance scores among basketball players and inferior balance scores may be a strong predictor of future ankle sprains, athletic trainers may find it useful to prescribe more balance training to basketball players than to soccer players. This is not to say that soccer players would not benefit from balance training but that balance exercises may be more necessary for basketball players.

Previous study compared the static and dynamic balance of regional level soccer players and national soccer players and found that national player's postural control was better than that of regional players, suggesting that elite players possessed a greater sensitivity of sensory receptors or better integration of information than latter players (5). In relation to this study we can say that, inclusion of more elite athletes in both groups might have shown more variations in the results. Due to unavailability of all the athletes in the morning session during the course of testing, the study was conducted irrespective of time of the day which might have greatly influenced the performance of various athletes. Previous studies concluded that performance on dynamic postural control task when compared to static postural control was found to be much better in the morning than in the afternoon or evening (13).

Conclusion

Study concluded that soccer and basketball players did not differ in terms of static balance on the BESS. In contrast, basketball players displayed inferior dynamic balance to soccer players on SEBT. Athletic trainers may find it useful to prescribe more balance training to basketball players than to soccer players. This is not to say that soccer players would not benefit from balance training but that balance exercises may be more necessary for basketball players. The results of the present study will help the trainers, coaches, clinicians and sports fraternity to develop an insight into balance demands of different sports like basketball and soccer etc, thereby helping them evaluating balance lacunae and designing appropriate balance training program for the designated sports. Also, athletic trainers can use these tests (SEBT and BESS) on athletes in sports that were not tested to help expedite the prescription of balance exercises.

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The use of infrared thermography for investigating abarticular rheumatism

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Abstract. *Objective*. Infrared thermography is a noninvasive physiological test which in 1990 was recognized as a diagnosis tool by the American Academy of Physical Medicine and Rehabilitation. The method is based on the identification and quantification of cutaneous thermal asymmetries. Several studies have been conducted so far, which showed thermographic variations in some soft tissue diseases, but could not reveal abnormal thermograms in one of the most common abarticular rheumatic disease – shoulder periarthritis. The purpose of this study was to emphasize the periarticular soft tissue disorders by digital infrared imaging, an infrared camera using the latest generation of high resolution infrared sensor. *Material and methods*. The study population was divided into two groups: a group of 81 patients with soft tissue disease and a control group (of similar size and demographic structure) composed of persons without pain at the sites of interest studied (shoulder, elbow, fist, hip, knee, Achilles tendon). The areas examined were the "regions of interest" for the various soft tissue disorders. *Results*. In all the subgroups studied the temperature difference between the affected region and the opposite side was higher than in the control group, the difference being statistically significant. *Conclusions*. Digital infrared imaging is a useful noninvasive, non-radiating, harmless and quick tool for investigating the inflammatory conditions of soft periarticular tissues.
Key words: *digital infrared imaging, epicondylitis, tendonitis, periarthritis, bursitis.*

Introduction

The relation between high body temperature and disease has been noticed since the beginning of medicine. In 1930, the University of Chicago made public one of the oldest medical texts, namely an Egyptian papyrus dating back to the 17th century B.C., which described the follow-up of the evolution of an inflamed and suppurating injury by local temperature determination, the measuring tool using being the doctor's fingers (1, 2).

Hippocrates was the first to have supported the importance of temperature monitoring. He used to diagnose tumors by applying wet mud on the patient's body, and he concluded that the tumor was where the mud dried faster, while the other body areas remained wet (3).

The next important step was Galileo Galilei's creation of the thermoscope in 1595, which allowed the monitoring of any temperature change against a reference value. In 1611 Santorio Sanctorius turns this thermoscope into a quantitative thermometer by drawing 110 equally spaced lines on the glass tube of the thermoscope. By means of this new tool, he was able to reveal human body temperature variations, which he associated with either health or disease (2, 4, 5).

In 1740, shortly after the introduction of the Celsius and Fahrenheit scales, George Martin published his conclusions related to normal body temperature. (2, 5). It was only a century and a half later that the first clinical thermometer was created by Carl Wunderlich, who published "On Temperature in Diseases" in 1898, where he drew comparisons between the temperatures of healthy and diseased individuals (2, 3). In his treaty, he pleaded for the routine use of thermometer to monitor temperature as part of patient care, yet his plea only led to Wunderlich's ostracism for his so-called anetic practices (3). In the 1930's, Knaus reemphasized the importance of body temperature measuring and set a modern of routine temperature check method. Yet, it was only two decades later that the method became generally accepted in clinical practice (4).

In 1800, Sir William Herschel discovered the caloric power of infrared sun radiation. His son, Sir John Herschel "visualizes" invisible infrared radiations by means of a specially processed paper using the evaporograph technique. He named the resulting image thermogram, which is still frequently used today (2, 6).

In 1934, Hardy proved that human skin emits

infrared radiations just like a black radiant body (3).

The early development of infrared technology was supported by the military technique of World War II, which made it available to industry and medicine at the end of the 1950's (2, 3). In 1957, R. H. Lawson of the Royal Victoria Hospital of Montreal defined the medical thermography field. This meant the beginning of the modern infrared thermography age (6).

Thermography or digital infrared imaging was born in 1970 when mini computers were connected to the infrared radiation detector to ensure image processing. These systems are able to take snapshots at high speed and still preserve high temperature accuracy (6).

The diseases that affect the vascular or nervous system, or the connective tissue will lead to temperature variations that may be detected by thermography.

These determinations were designed to identify and quantify cutaneous thermal asymmetries. The thermographic identification of the painful areas was traditionally done by comparing a particular body area with its opposite side and using the pain-free area as reference. Thus, the body areas are either symmetrical or asymmetrical as concerns temperature. Research has shown that thermal symmetry is well preserved in the opposite areas in the absence of pain. The temperature difference between the corresponding opposite areas was found to be 0.24±0.073°C in normal individuals; the temperature difference s between the corresponding areas are not only very small but also very stable throughout the derma (7, 8).

Due to thermal symmetry preservation in the opposite areas in case of absence of pain or of presence of bilateral pain, another thermogram analysis approach was proposed. Thus, the average normal cutaneous temperature and standard deviations were determined for 28 cutaneous areas. The average cutaneous temperature was found to vary depending on the location of the studied area, as distal areas had lower temperatures (9).

The thermal index was calculated as the average temperature difference calculated against the reference temperature, after the later had been determined by a study performed on 600 normal subjects, in whom the average ankle, knee, hand, elbow and shoulder temperatures were determined. The normal index, read in the control groups ranged from 1 to 2.5. In inflammatory arthritis this number increases to 4 – 5, whereas in arthrosis the increase is less significant (3 – 4). In gout and infections the values exceed 6 – 7 on this scale (10, 11).

The etiological/triggering factor of most cases of soft periarticular tissue diseases (tendonitis, tenosynovitis, bursitis, enthesitis) is mechanical overstrain, which occurs frequently in sports-related pathology. In fact, some of these diseases bear the name of the sports in which they are the most common; for instance: tennis elbow (external epicondylitis), golfer's elbow (internal epicondylitis), jumper's knee (patellar tendinopathy), runner's knee (illio tibial band friction syndrome), tennis leg (distal medial gastrocnemius tear often associated with thin plantaris tendon rupture).

Several studies have been conducted so far, which showed thermographic variations in some soft tissue diseases, but could not reveal abnormal thermograms in one of the most common abarticular rheumatic disease – shoulder periarthritis.

Hand tenosynovitis was successfully detected by cutaneous temperature determination (12). Olecranon bursitis may be pointed out is a hot area adjacent to the olecranon (13).

Any pain in the elbow extensor insertion points is associated with hot thermogram areas (14). Thermography may detect insertion tendinopathy just as isotopic scintigraphy (15). Also, the hot elbow areas are strongly correlated with pressure-induced pain threshold decrease (16). These hot areas were used as therapy monitoring parameter (17, 18). Hot areas on both elbows were detected in patients suffering from fibromyalgia (19).

The pain caused by tendinous insertion conditions in the internal epicondyle is often called golfer's elbow. Although it is almost identical to tennis elbow in what concerns its pathophysiology, any temperature variations are rarely detected in this disease (20).

The term shoulder periarthritis includes a series of periarticular tissue conditions affecting the shoulder joint. The most common problems are related to supraspinatus and subspinatus muscle insertion pathologies, often associated with a subacromial impingement syndrome. Long-term variations may determine specific radiological or echographic snapshots, although there are no specific temperature variations caused by this condition (21, 22). Nevertheless, prolonged

mobility decrease will lead to shoulder hypothermia (21-24).

The aim of this study was to emphasize the periarticular soft tissue disorders by digital infrared imaging, a noninvasive physiological test, which consists of getting a cutaneous temperature distribution map with an infrared camera using the latest generation of high resolution infrared sensor.

In abarticular disease, thermography may reveal local inflammatory and vasomotor reaction by local temperature increases and/or altered cutaneous thermal map appearance, knowing that the thermal symmetry principle is normally observed. The thermographic snapshots were taken using a Flir B335 thermovision camera with an infrared sensor resolution of 320 x 240 pixels, with 0.05 °C sensitivity and 7.5 – 13µm spectrum.

Material and Methods

The study population was divided into two groups: a group of 81 patients with soft tissue disease and a control group (of similar size and demographic structure) composed of persons without pain at the sites of interest studied (shoulder, elbow, fist, hip, knee, Achilles tendon).

The study inclusion criteria were: suggestive symptomatology for abarticulary rheumatism onset on less than three weeks, presence of suggestive ultrasound changes. The exclusion criteria: previous or concomitant AINS treatment, local/general corticotherapy, neoplasia, infectious cutaneous lesions.

The patients included in the study were clinically examined by soft part ultrasound (to have the diagnosis confirmed) and digital thermography.

Thermographies were performed in a special room, at a comfortable room temperature (20–24°C), without radiating heat sources (illumination by cold light sources), with the trial space thermoisolated by panels.

The patients adapted to this environment for 15 minutes before the investigation started, in order to reach the thermal balance.

The examined areas were the areas targeted by various soft tissue disorders.

For the shoulder joint we examined: the anterior side (corresponding to the bicipital groove), and the lateral side (the greater humerus tuberosity) and the posterior side (the scapular spine and the acromion).

As for the hip joint, we examined the lateral side (the area corresponding to the greater trochanter). For the elbow joint, we examined the lateral epicondyle (the point of insertion of the common extensor digitorum). As for the ankle joint, we examined the posterior side – the area of insertion of the Achilles tendon on the calcaneus. In the case of the fist joint, we examined the area of the radial fossa (long abductor and extensor pollicis brevis tendons).

As for the knee joint, we examined the anterior side (rotulian tendon, suprapatellar bursitis) and the median side (tendon inserts that make up the „goosefoot”).

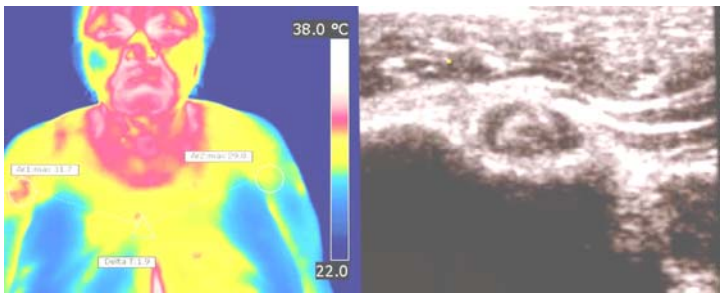

Figure 1. Right shoulder periarthritis – thermography (Δt=1.9°C) and ultrasonography (tendonitis and peritendonitis of brachial biceps)

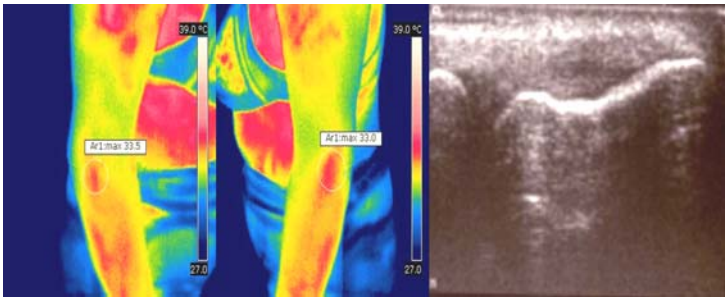

Figure 2. Lateral epicondylitis – thermography (ΔT=0.5°C) and ultrasonography (thickening of extensor tendon)

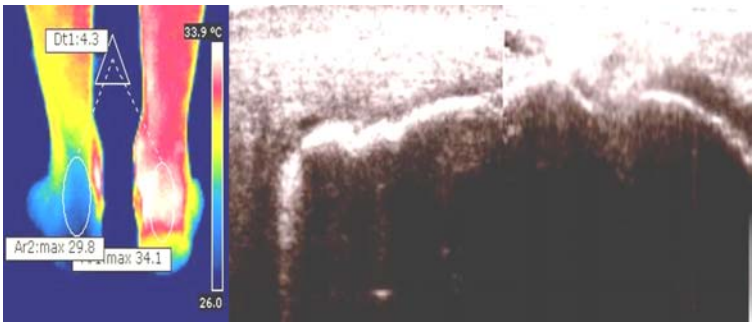

Figure 3. Achilles tendonitis, calcaneal tuberosity bursitis and supracalcaneal bursitis – thermography (ΔT=4.3°C) and ultrasonography (Achilles tendon thickening at the insertion on the calcaneus; tuberosity bursitis)

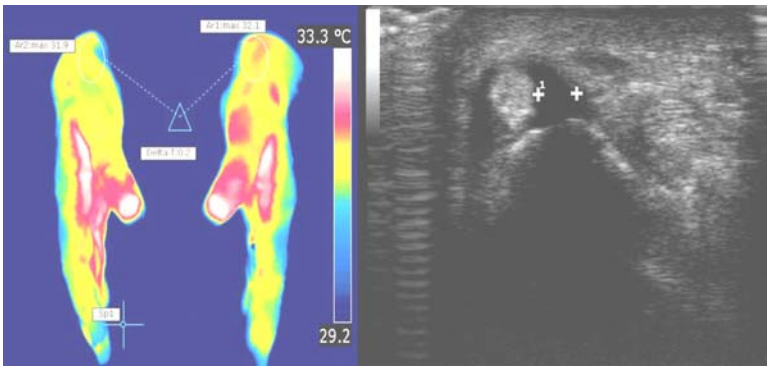

Figure 4. Left Quervain tendonitis – thermography (ΔT=0.2°C) and ultrasonography (fluid effusion in tendon sheath)

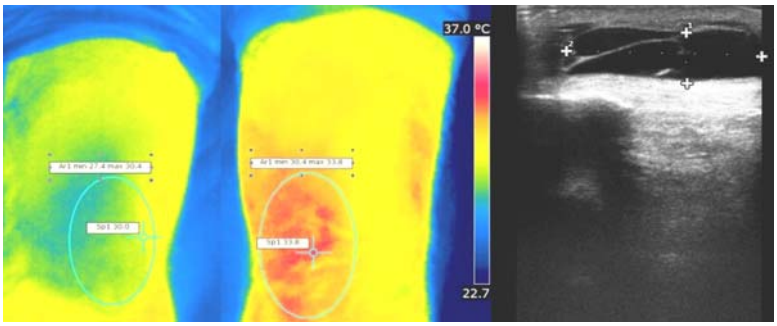

Figure 5. Prepatellar bursitis – thermography (ΔT=3.4°C) and ultrasonography (fluid effusion in prepatellar bursae)

Results and Discussions

The control group included 49 women and 32 men, with an average age of 48,56 years. The average age was lower in the group with tendonitis and higher in the group with coxo-femoral and scapulo-humeral periarthritis. Regarding the studied soft tissue condition types, a predominance of the shoulder periarthritis is noticed (50%).

In the control group, the temperature difference s between the symmetrical areas ranged from 0 to 0.4°C, the mean of these differences being below 0.2°C for all subgroups (made according to the studied area of interest), which is within the norms stipulated in literature according to which there can be a difference of maximum 0.2°C between two symmetrical opposite regions

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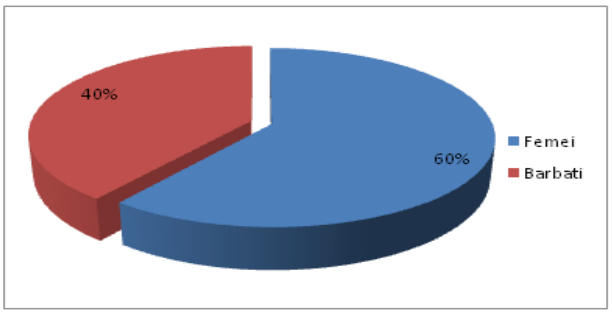

Figure 6. Gender distribution of patients of the control group

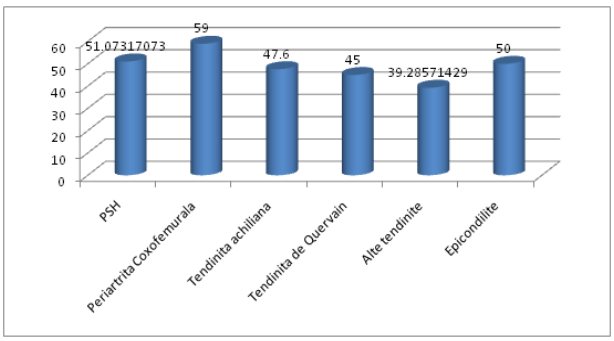

Figure 7. Average age of the patients of the studied subgroups

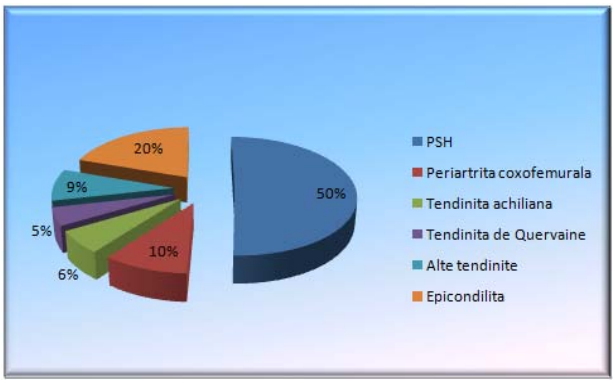

Figure 8. Distribution of the soft tissue condition types in the study group

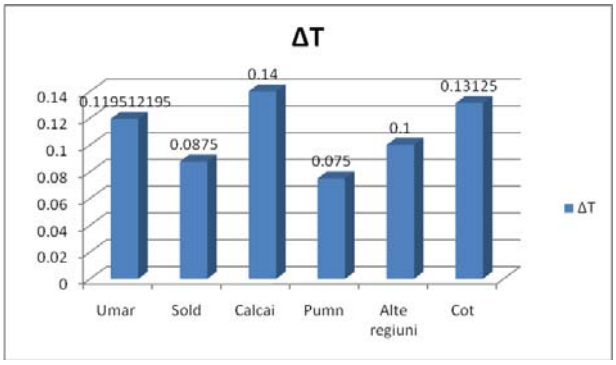

Figure 9. Temperature difference against the opposite region in different areas in individuals without symptoms in those regions

In the scapulo-humeral periarthritis subgroup, the temperature difference between the impaired region and the clean opposite one varied between 0 and 2.1°C, with an average of 0.57°C, i.e. 0.45°C higher than the average value of the relative control group, a difference that is statistically significant (p=0.0000).

As concerns the coxo-femoral periarthritis subgroup, the temperature difference between the affected area and the clean opposite one ranged from 0 to 0.7°C, with an average of 0.31°C, i.e. 0.22°C higher than the average value of the corresponding control group, a difference which is statistically significant (p=0.031).

In Achilles tendonitis, the temperature difference between the affected area and the clean collateral one varied between 0.9 and 4.3°C, with an average of 2.04°C, i.e. 1.9°C higher than the average value of the corresponding control group, a difference that is statistically significant (p=0.007).

In the Quervaine tendonitis subgroup, the temperature difference between the affected region and the clean opposite one ranged from 0.5 to 0.8°C, with an average of 0.625°C, i.e. 0.55°C higher than the average value of the corresponding control group, a difference that is statistically significant (p=0.0002).

In the subgroup with other tendonitis conditions, the temperature difference between the affected region and the clean opposite one varied between 0.4 and 3.7°C, with an average of 1.43°C, i.e. 1.33°C higher than the average value of the corresponding control group, a difference that is statistically significant (p=0.003).

As far as the epicondylitis subgroup is concerned, the temperature difference between the affected region and the clean opposite one ranged from 0.3 to 2.2°C, with an average of 0.89°C, i.e. 0.76°C higher than the average value of the corresponding control group, a difference that is statistically significant (p=0.0000).

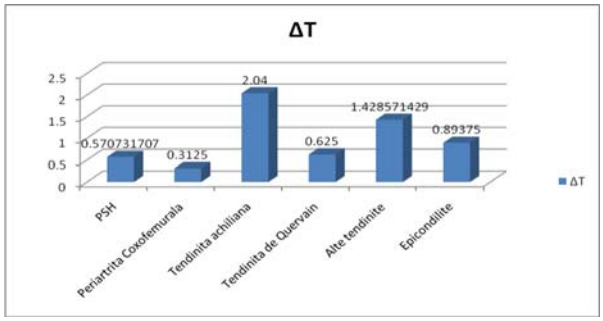

Figure 10. The temperature difference between the affected area and the opposite one in different conditions

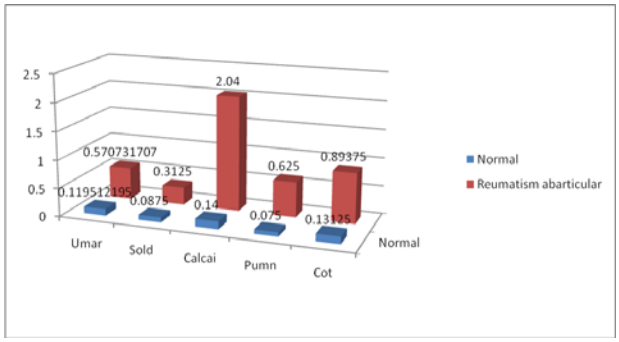

Figure 11. The temperature difference between the symmetrical opposite areas in normal and pathological situations

Analyzing the values obtained in the case of the subgroups represented by patient with different conditions of the periarticular soft tissues and comparing them to the results obtained in the case of the control group, we noticed that the thermographic determination is a reliable tool for investigating the inflammatory conditions of the periarticular soft tissues. We also noticed that in the case of shoulder periarthritis, although there are no significant temperature variations in all the cases, when these rely on the thermal shoulder map, the tendon / tendons involved in the inflammatory process can be identified accurately enough. Whereas in tendonitis and epicondylitis the temperature difference does not generally exceed 2°C as compared to the opposite area, in case of bursitis the temperature difference is higher than 3°C (in a case of Achilles tendonitis with calcaneal tuberosity bursitis and sub-Achilles bursitis it reached 4.3°C).

Conclusions

Thermography is a useful periarticular soft tissue investigation tool that can prove its value especially in monitoring the evolution under treatment of abarticular rheumatism. The thermal gradient is greatly increased when the serous bursa is also involved in the inflammatory process, with liquid accumulation; the gradient increase seems to be proportional to the quantity of accumulated liquid, but further studies are necessary in order to establish a correlation.

As concerns the conditions affecting the periarticular soft tissues around the joints surrounded by a well developed muscular mass (hip, shoulder), the thermal image and the temperature difference do not always vary, probably due to the masking inflammatory phenomena of the muscular labor.

In case of shoulder tendonitis related to scapulo-humeral periarthritis, when the thermal image is modified, it is well correlated with the clinical exam and with the ultrasound exploration, and it provides information on the affected tendon.

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Non invasive evaluation of cardiac dimensions in professional wrestlers

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Abstract. *Aim***.** In order to investigate the effect of strength training on cardiac dimensions, two groups, wrestlers and control group were analysed noninvasively by transthoracic echocardiography. The results are compared with other published data to study the characteristics of Athlete's heart in Indian wrestlers. *Material and Method.* The participants included 60 subjects aged between 18-24 years. Main outcome measures were left ventricular concentric hypertrophy and enlargement in wrestlers. Left ventricular end diastolic dimension {(LVED) (5.15±0.40 vs 4.2±0.55cm p <0.001)}, inter-ventricular septal thickness {(IVS) (1.23±0.15 vs 0.93±0.11cm p <0.001)}, posterior wall thickness {(PWT) (1.07±0.21 vs 0.87±0.12cm, p <0.001) were found to be significantly higher in wrestlers. Heart rate (74.53±0.55bpm) was found to be significantly higher in control group depicting sinus bradycardia in wrestlers. *Results and* c*onclusion.* Chronic physical strength training result in changes in cardiac dimensions such as myocardial wall thickening and thus leads to athlete's heart characterised by concentric left ventricular hypertrophy and enlargement in wrestlers.
Key words: *athlete heart***,** *echocardiography, wrestlers*.

Introduction

Regular participation in competitive sports causes moderate left ventricular (LV) hypertrophy accompanied by morphologic alteration in cardiac function which is known as "Athlete's Heart" (1, 2). It is generally regarded as benign increase in the cardiac mass that represents a physiological adaptation to systematic training (3-19). The type and extent of hypertrophy depends on the intensity and type of training (20). Chronic physical training induces morphological and useful adaptations which affect all the cardiac chambers and it is said that these adaptations seem helpful for performance (21).

The notion that strength based training leads to concentric LV hypertrophy and endurance based training leads to eccentric LV enlargement was first given in 1975 (4). It led to the concept that sports induces cardiac remodelling, depending upon the type of exercise. However, the clinical concept of athlete's heart has now expanded over many years as accessibility to larger number of athletes and general population taking more interest in sporting activities has increased invariably.

The clinical profile of athletes has also expanded considerably as a result of greater accessibility to echocardiography, electrocardiography, magnetic resonance and Holter monitoring. Thus there has been increasing recognition of the impact of sports conditioning on cardiovascular system which may eventually mimic pathological conditions like hypertrophic and dilated cardiomyopathy with the potential of sudden death.

Sudden deaths of trained and elite athletes, over last few years have become highly visible incidents on field and during exercise which have laid substantial impact on the sports physician. So, interest in cardiac remodelling of athletes in different sports, awareness of the underlying condition, clinically identifying cardiovascular disease and the availability of diagnostic techniques to prevent sudden death has accelerated lately (3, 22-24).

Echocardiography is non invasive and repeatable imaging tool now being largely used to distinguish between pathological and physiological changes in the Athlete's heart. It allows an evaluation of the heart's functional and structural adaptations in response to training. The first echocardiography study suggested that intense isometric exercise training results in

concentric LV hypertrophy due to increased ventricular wall thickness (normal being septal/posterior wall ratio <1.3) (4). Meta-analysis done by Pluim et al (1) has now suggested the concept that the strength trained group (wrestlers, weight/power lifters, body builders, throwers) who are considered to develop pure concentric LV hypertrophy demonstrate increase in wall thickness and significant enlargement in LV internal dimension.

So in the present research we intend to offer an assessment of cardiac morphological dimensions in wrestlers that target the inter relation of isometric training (strength training) with cardiac structure by transthoracic echocardiography. And then compare the results with published data of other studies.

Material and Method

Subjects. 60 subjects were involved in the study, wrestlers (n=30) and healthy controls (n=30) with mean age of 18 to 24 years (21.18±1.535). All athletes had minimum experience of 3 years of strength training and control group did not participate in any sporting activity. All readings were taken in the competitive season just before a inter university competition. The whole study group was considered free of structural heart disease on the basis of their medical history, physical examination and electrocardiography. None of the wrestlers reported use of anabolic steroids. Written informed consent was obtained by all study participants and the study protocol was approved by the ethical committee of the institution.

Parameters. Two-dimensional and M-mode echocardiography was performed on all the subjects in the morning after their regular conditioning workout (using Philips iE33, X-matrix, USA). Measurements of left ventricular end–diastolic dimension, septal and posterior wall thickness were taken through M-mode echocardiography. The focus of the study was to see the cardiac dimension changes in the wrestlers as compared to the control group owing to strength training.

Electrocardiography (ECG): All athletes and controls underwent 12-lead ECG in the supine position just before echocardiography and all had normal ECG criteria for participating in the study and none reported any structural cardiovascular disease.

Statistical analysis. SPSS software (version 16.0) was used for statistical analysis. All data are expressed as mean± standard deviation (SD) in the following tables 1-3. Differences between means were assessed by independent samples t-test. A two tailed p <0.05 was considered statistically significant.

Results

The subjects under study were aged between 18 to 24 years (21.18± 1.535) and weighed between 50 and 122 kilograms (69.87±13.22). The anthropometric data of both the groups is represented in Table I. Height (171.87±4.91) and body surface area (1.86±0.18) were found to be significantly higher in wrestlers.

The indices of cardiac morphology and dimensions of both the groups are presented in Table II.

No pathological and structural defects in the myocardium were evident during the echocardiography of all the subjects.

The statistical analysis has revealed that most of the cardiac parameters were significantly higher in the wrestlers.

According to our findings given in table II, an average LVED dimensions (5.15±0.40 vs 4.2±0.55cm p <0.001), IVS (1.23±0.15 vs 0.93±0.11cm p <0.001), PWT (1.07±0.21 vs 0.87±0.12cm P=0.001), heart rate (63.20±5.20 vs 74.53±3.02bpm, p <0.001) were significantly higher in wrestlers than those of control group except for heart rate which was found to be higher in control group.

The results of comparison between the two groups are given in figure 1. In table III, the echocardiographic studies done on strength trained group to see the effect of strength training are shown to compare our results with the published studies.

Table I. Anthropometric data of wrestlers and control group. Quantities represented are mean ± standard deviation and the p-value obtained after independent samples test

Variant	*Wrestlers*	*Control*	*p-Value*
Age	20.73 ± 1.202	21.63 ± 1.712	.022
Height	171.87 ± 4.918	163.47 ± 9.417	.001
Weight	74.43 ± 15.54	65.30 ± 8.417	.006
Body Surface Area (BSA)	1.86 ± 0.18	1.70 ± 0.13	.001

Table II. Echocardiographic parameters of the subjects represented by mean ± standard deviation and p-value.the readings are in centimetres

VARIANT	*WRESTLERS*	*CONTROL*	*P-value*
LVED	5.15±0.40	4.21±0.55	<0.001
IVS	1.23±0.15	0.93±0.11	<0.001
PWT	1.07±0.12	0.87±0.12	<0.001
HR	59.20±5.20	74.53±0.55	<0.001

Table III. Cardiac characteristics in strength trained athletes reported in various studies

AUTHORS	*LVED (mm)*	*PWT (mm)*	*IVS (mm)*
MorganRoth et al (1975) (4)	50.0	1.35	1.38
Pellicia et al (1991) (7)	52.6 ± 5	10.2 ±0.9	NR*
Pluim et al (2000) (1)	52.1 (50.6-53.6)	11 (10.2-11.7)	11.8 (10.9-12.7)
Venckunas et al (2008) (20)	54.0 ± 3.6	11 ± 0.4	11.5 ± 0.6
Our study	51.5 ± 0.4	10.7 ± 0.2	12.3 ± 0.15

*NR= Not Reported

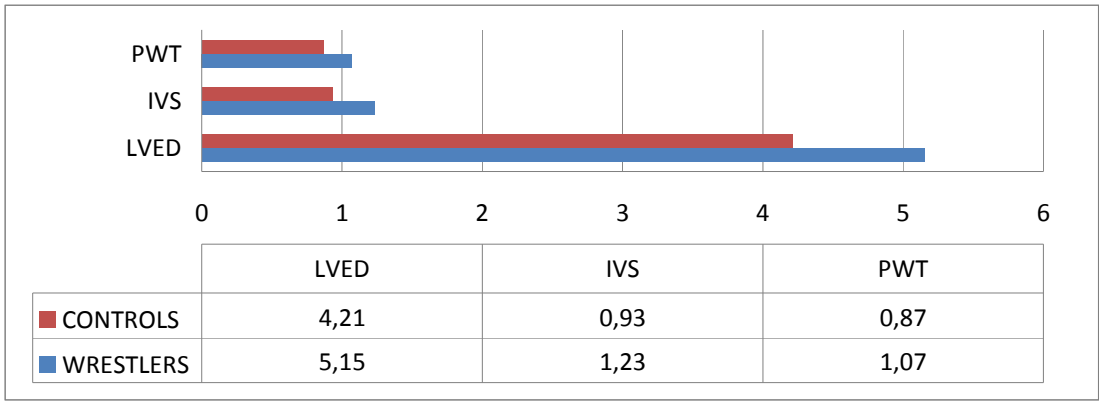

Figure 1. Distribution of left ventricular end diastolic dimension (LVED), inter-ventricular septal thickness (IVS), posterior wall thickness (PWT) in wrestlers and controls. All readings are in centimetres

Discussion

The main purpose of our study was to see the relationship between strength training and echocardiographic heart dimensions. The second objective was to compare the results with control group and other published data to study the characteristics of Athlete's heart in wrestlers.

Findings about cardiac morphological variables by the echocardiography in this study showed that wrestling as a static exercise has the greatest impact on ventricular wall thickness (inter-ventricular septum and left ventricular posterior wall thicknesses).

The results of our study supports the notion that regular strength exercise induces cardiac remodelling that is manifested by LV wall thickening and hypertrophy in wrestlers.

The data is in accordance with the results of meta-analysis done by Pluim et al (1).

*Myocardial wall thickness***:** It has been shown that myocardial wall thickness increases in the strength trained group (4). Our study revealed significant higher readings in the inter-ventricular septal (IVS) and posterior wall thickness (PWT); in the wrestlers when compared to the control group.

The increase in myocardial thickness has been shown to result in concentric hypertrophy in wrestlers. The majority of athletes studied by M-Mode echocardiography show symmetric ventricular posterior free wall and septal thicknesses (normal being septal/posterior wall ratio <1.3).

But some reports (29, 30) have described a small number of athletes exhibiting an increased septal/free wall ratio suggesting an asymmetric pattern of left ventricular hypertrophy.

Although septal/posterior wall thickness ratios were greater than 1.3 in four athletes in our study, the mitral valve echo was entirely normal in these individuals. Thus, despite the presence of what has previously been described as a criterion for asymmetrical septal hypertrophy, there is no evidence to support a diagnosis of hypertrophic obstructive cardiomyopathy in any of our subjects (27). Thus the increased wall thickness is related to the pressure load imposed by strength exercise.

Left ventricular cavity: Morgan Roth et al in 1975 proposed that endurance based exercise and strength based exercise lead to distinctly different changes in the left ventricular dimensions (4). But numerous data now has refuted this concept (1, 25-26) as extreme forms of both subtypes are encountered. It has been shown that left ventricular dimension can also be increased in the strength trained group which is also seen in our study.

Heart rate: Regular physical training in athletes is associated with a high prevalence of sinus bradycardia (heart rate < 60bpm) (28). Resting bradycardia was present in our experimental group and has been frequently noted by others (23). Experience from other studies on athletes indicates that such change reflects increased vagal tone and increased cardiac size.

From the earlier published data we can see that despite the racial or ethnic differences the results are approximately similar in all the groups, giving us an insight that strength training has direct link to cardiac morphological adaptations excluding ethnic or racial link.

Conclusion

The echocardiographic parameters were significantly higher in the wrestlers as compared to the control group concluding that chronic physical strength training result in myocardial wall thickening and thus leads to concentric hypertrophy in wrestlers with ventricular enlargement to a small extent is also seen.

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A study on the fitness level among students of Victor Babes University of Medicine and Pharmacy Timisoara

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Abstract. *Introduction*. Physical inactivity is a risk factor for obesity that in turn is a risk factor for pathological conditions. The objectives of the research were to assess the fitness level among medical students, to determine their body mass index, whether they practise sports or not, during an academic year. *Material and method.* A questionnaire was used to assess the fitness level of the first and second year medical students of the "Victor Babes" University of Medicine and Pharmacy. The study was completed between October 2011 and May 2012. *Results*. Group 1 consisted of 569 students: 433 females (76.23%) and 135 males (23.77%) who attended the physical education and sports classes, but did not practised competition sports. Group 2 consisted of 53 students: 20 females (37.74%) and 33 males (62.26%) who practised competition sports (basketball, volleyball, football) and played in the university teams. Group1 had the following characteristics: age 18-44 years, height 150 – 185 cm, weight 40-155 kg, BMI 15.6 – 35.4. Group 2 had the following characteristics: age 19-28 years, height 162 – 195 cm, weight 55-113 kg, BMI 17.6 – 30.9. In group 1, 13.56% of the students were underweight, 9.15% overweight, 1.94%, obese and 75.35%cnormal weight. In group 2, 5.77% of the students were underweight, 5.77% overweight, 3.85% obese, and 84.62% normal weight. *Conclusion.* Regular physical activity is essential for the prevention of overweight and obesity.
Key words*: fitness, physical condition, medical students, BMI.*

Introduction

Due to the radical changes that have occurred in people's lifestyle in industrialised countries in the past centuries, most individuals consider that physical exercises are no longer necessary.

The less people take daily physical activity, the more they are affected by pathologic diseases caused by a sedentary life style.

Excess weight and inactivity are frequent themes debated in the mass-media. They are considered major aspects with a negative impact on adolescents' physical condition (there are fewer references on too low body weight, though it has similar consequences). Inactivity is a risk factor associated with obesity which in turn is a risk factor for other chronic diseases (1-5).

In order to initiate working programmes with non-sportive students and competitive sportive students to form an assertive type of behavior, one should initiate preliminary studies about the image people have about themselves.

This is the purpose of this study, which is based on a questionnaire.

The objectives are: to assess the fitness level among medical students, whether they practice sports or not, during a university year and to assess the body mass index of medical students, whether they practice sports or not, during a university year.

Material and method

This study is based on a questionnaire regarding the fitness level of the first and second-year medical students of the "Victor Babes" University of Medicine and Pharmacy.

The instrument is part of a study investigating the prevalence of overweight and obesity, physical activity, sedentary behavior and weight control methods used by medical students in Timisoara.

It was carried on between October 2011 and May 2012 and included two student groups.

Group 1, included students who attended the physical education classes, but they did not or had not practised competition sports.

Group 2, included students who practised sports (basketball, volleyball, football).
Anthropometry was used to determine height (m) and weight (kg), in relation to the criteria of sex and age.
Body mass index (BMI) was calculated with the formula: BMI = Weight in Kilograms/(Height in Meters x Height in Meters). According to the World Health Organization, the BMI values are classified as follows: below 18.49kg – underweight, 18.50-24.99 – normal weight, 25.00-29.99 – overweight, 30.00 and higher – obese.
Statistical analysis. A computerized database was formed using Micrsosoft Excel software. All analyses were conducted with Stata 9.2 (Statacorp, Texas, USA). The results are presented as absolute and relative frequencies. Student's t-test was used to compare mean values between group 1 and group 2.
Chi-square tests were used to compare frequency distributions between groups.

Results

Group 1 consisted of 569 first and second-year students, of which 433 were female (76.23%) and 135 were male (23.77%). Group 2 consisted of 53 students who practised competition sports (basketball, volleyball, football) and played in the university teams. Among them, 20 were female students (37.74%) and 33 were male (62.26%). Group 1 had the following characteristics: age between 18 and 44, height 150 - 18cm, weight between 40 and 155kg, BMI 15.6 – 35.4. Group 2 had the following characteristics: age between 19 and 28, height 162 - 195cm, weight between 55 and 113kg, BMI 17.6 – 30.9.
Distribution of participants by year of study, gender, BMI. As seen from the results and as expected, group 2 has a significant higher BMI (p=0.0254) owing to physical exercise and the high number of hours spent in sports practising. It should be mentioned that the curricula of the medical university does not allow students to spend too many hours in training per week.

Table I. BMI comparison between group 1 and 2

BMI	Frequency	Mean	Std. Dev	P value
Group 1	568	21.42	3.03	0.0254
Group 2	52	22.40	2.78	

Table II. Distribution of participants by year of study, gender, BMI

		Group 1		Group 2		P value
		Frequency	*Percentage*	*Frequency*	*Percentage*	
Year of study	I	192	33.74%	3	5.66%	<0.001
	II	377	66.26%	50	94.34%	
	Total	569		53		
Gender	Female	433	76.23%	20	37.74%	<0.001
	Male	135	23.77%	33	62.26%	
BMI	underweight	77	13.56%	3	5.77%	0.239
	normal weight	428	75.35%	44	84.62%	
	overweight	52	9.15%	3	5.77%	
	obese	11	1.94%	2	3.85%	

Table III. Distribution of students in group 1 by BMI category

BMI	Frequency	Mean	Std. Dev
underweight	77	17.66	0.62
normal weight	428	21.16	1.68
overweight	52	26.88	1.49
obese	11	31.78	1.94

Table IV. Distribution of students in group 2 by BMI category

BMI	Frequency	Mean	Std. Dev
underweight	3	18.10	0.41
normal weight	44	22.01	1.67
overweight	3	26.89	2.24
obese	2	30.80	0.21

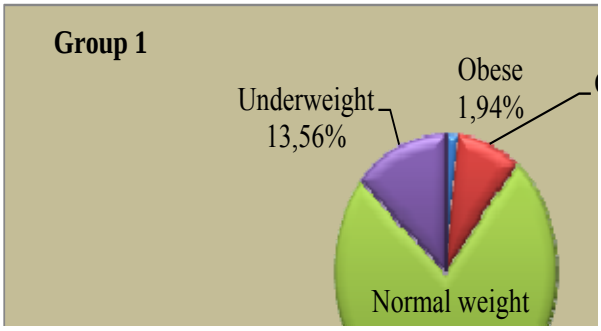

Figure. 1 Distribution of students in group 1 by BMI category

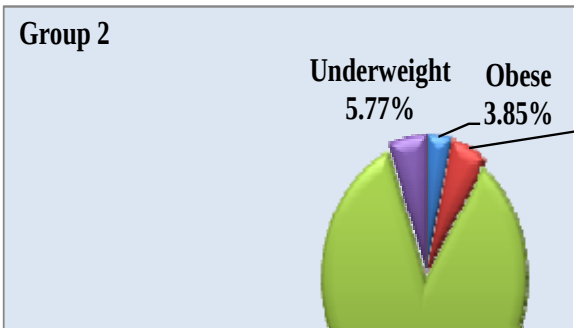

Figure 2. Distribution of students in group 2 by BMI category

Self-perception of weight by the participants

Table V. Self-perception of weight by the participants

	Group 1		Group 2	
	Frequency	*Percentage*	*Frequency*	*Percentage*
A. Much below the normal weight	6	1.06%	0	0
B. A little below the normal weight	55	9.68%	8	15.09%
C. About normal weight	309	54.40%	39	73.58%
D. A little over normal weight	155	27.29%	5	9.43%
E. Much above the normal weight	43	7.57%	1	1.89%

On summarising the data provided by the participants regarding self-perception of weight, the following resulted (Table V): Group 1 – 309 (54.40%) participants considered they have normal weight, 155 (27.29%) were a little over normal weight, 55 (9.68%) were a little below normal weight and 43 (7.57%) were much above normal weight;

Group 2 – 39 (73.58%) participants considered they have normal weight 5 (9.43%) were a little over normal weight, 8 (15.09) were a little below normal weight and 1 (1.89%) were much above normal weight.

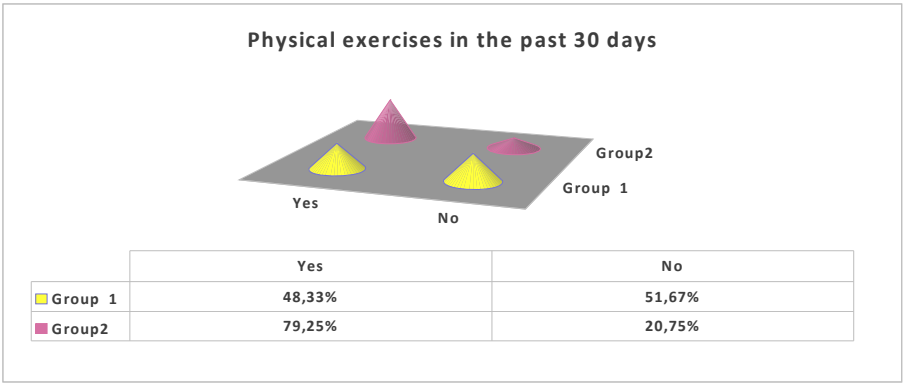

Figure 3. Distribution of the students who have/have not done physical exercises in order to lose weight or avoid putting on weight during the previous 30 days

Exercise to lose weight or not gain weight in the last 30 days.

There are significant differences (P<0.001) in preventing weight gain through physical exercises and a healthy life style between group 1 and group 2.

Group 1. Students attending physical education classes (2h/week), Fig 3, answered yes – 275 (48.33%), and no - 294 (51.67%). There are no significant differences in the number of training sessions and physical exercises between the participants who said YES and those who said NO.

Group 2 (sportive students). There are significant differences in preventing weight gain by physical exercises and a healthy lifestyle between the participants who said YES - 42 (79.25%) - and those who said NO – 11 (20.27%) of the 53 participants.

In the last 30 days to prevent weight gain or to the weak, participants ate or drank less food lower in calories and fat.

When asked if they ate low-calorie food or ate less to avoid weight gain (Fig 4), the participants who answered YES were much more than those who answered NO (59.23% sportive students, 62.26% non-sportive students).

The difference is not statistically significant (P=0.186). Our data show that the participants in the study prefer eating less than doing physical exercises.

Participation in physical education classes and sports is shown in figure A small proportion of students in group 1 (3.16%) have medical exemption (Fig 5). However, attendance is compulsory even for students with medical exemption who take part in recovery programmes.

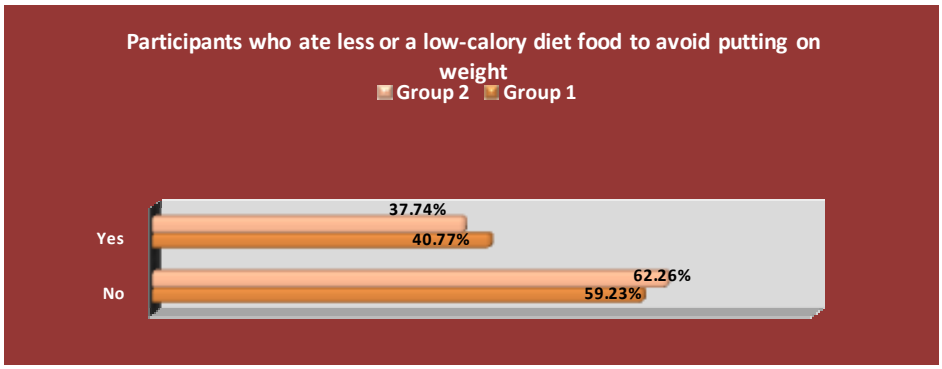

Figure 4. Distribution of the students who ate less or ate low-calorie food to avoid gaining weight in the previous 30 days

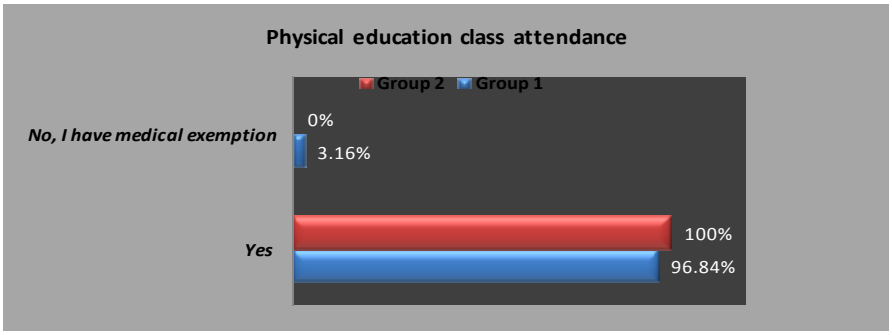

Figure 5. Physical education class attendance

Action taken by participants on body weight in the near future

The percentage of the option "To lose weight" (Fig.6), is high in both groups: group 1 (48.33%), group 2 (26.42%). The big difference between the two groups is due to the fact that sportive students have large muscle mass and optimal and stable body weight, while the non-sportive students who attend the physical education classes have low muscle mass and much adipose tissue.

Two questions were asked relating to the number of days students undertake physical activity of at least moderate intensity for at least 60 minutes.

Physical activity is considered any activity that increases heart rate and makes the student get out of breath some of the time.

Physical activity can be done in sports, academic activities or walking to university. Some examples of physical activity are running, brisk walking, bicycling, roller-blading, dancing, practicing skateboarding, swimming, football, basketball, etc.

To answer these two questions students were asked to take into account the physical activities they do every day. In the past 7 days, the participants were physically active 60 minutes/day - the mean for both groups was 4 days a week (Fig 7). In a regular week, the participants were physically active 60 minutes/day - the mean was 4-5 days a week as well (Fig 8).

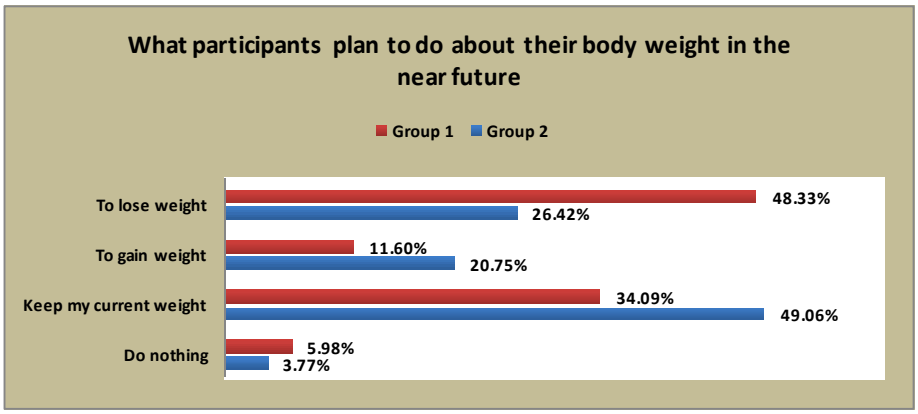

Figure 6. What participants plan to do about their body weight in the near future

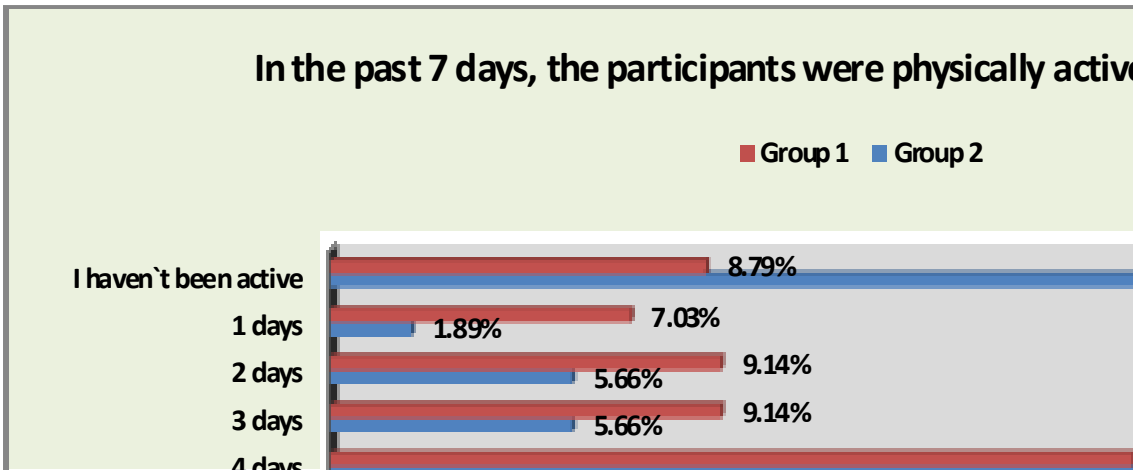

Figure 7. Distribution of students according to their physical activity in the past 7 days

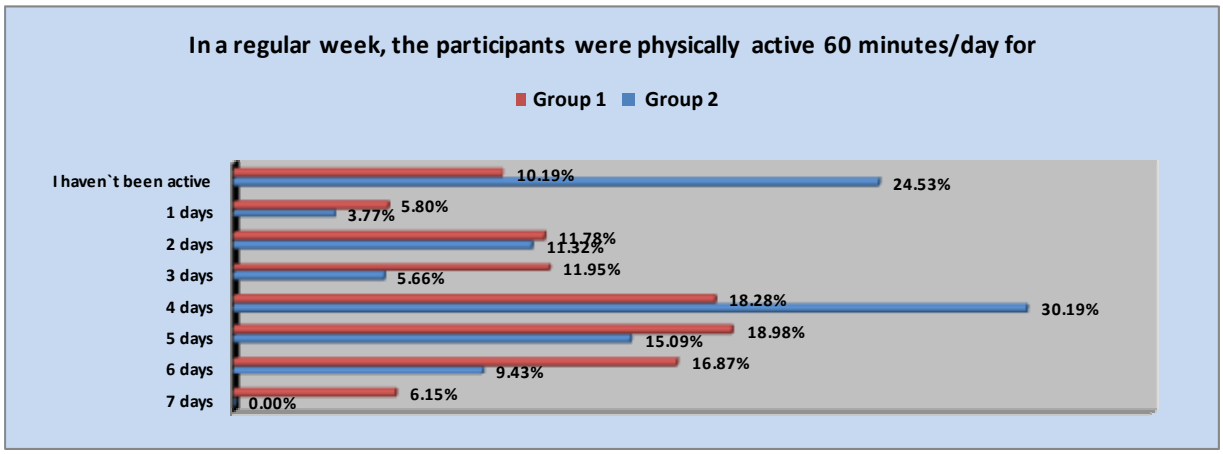

Figure 8. Distribution of students according to their physical activity during a regular week

Discussions

Literature data estimate that annual physical inactivity (WHO) is responsible for 1.9 million premature deaths in the entire world, and that 600 000 (approximately one third) of these occur in the European Region (53 countries) (6). The statistics show that 17% of the adult population of the world is completely physically inactive, and a percentage of 41% while doing some physical activity, this movement is insufficient for them to benefit (6).

"The study on young people's lifestyles and sedentariness and the role of sport in the context of education and as a means of restoring the balance", conducted by two German authors, in cooperation with specialists from England, Portugal, Denmark, Finland, Lithuania, Sweden, the Czech Republic, the Netherlands and Belgium (7) came to the following conclusions: in a 2002 study on 6000 children aged 12-15 years, from six European countries (Belgium, Germany, Estonia, Finland, Czech Republic and Hungary), recreational sport was placed in 6th position and participation in organized competitive sports in the 9th position in a list of leisure activities.

From another source than the study mentioned above, it results that about two thirds of the young people do not meet the requirements for physical activity. In other words, only 30-40% of the young population performs the recommended amount of physical activity. There are big differences between countries, however, in 13 of the 25EU countries, the percentage of girls aged 15years who meet the requirements, is less than 20%. The authors conclude that, unfortunately, there is not yet a consensus on the issue of "optimal level of aerobic fitness" for children and adolescents, making it difficult to respond argued if European youth are well prepared physically(7).

Sportive participants (Group 2) used to practising a sport have more self-esteem, are used to spend more hours on training and choose a moderate diet. Non-sportive participants (Group 1) do not practise any physical activity except for the physical education classes, are used to this lifestyle and make no effort to improve it.

According to BMI classification, the results of the participants in the study are as follows: Group 1. (students who do not practice sports) 15.62 – 35.49; 75.35% (428 participants) normal weight, and 13.56% (77 participants) underweight 1,94%; Group 2.(students who practice sports) 17.63 - 30.96; 84.62%(44 participants) normal weight, 5.77% (3 boys) overweight, 5.77% underweight (3 girls), 3.85% (2 boys) obese. The two obese boys are tall basketball players (195 cm - centers) with large muscle mass.

On summarising the data provided by the participants regarding self-perception of weight, the following resulted: (Table V): Group 1 – 309 (54.40%) participants considered they have normal weight, 155 (27.29%) were a little over normal weight, 55 (9.68%) were a little below normal weight and 43 (7.57%) were much above normal weight; Group 2 – 39 (73.58%) participants considered they have normal weight 5 (9.43%) were a little over normal weight, 8 (15.09) were a little below normal weight and 1 (1.89%) were much above normal weight.

There are significant differences ($P < 0.001$) in preventing weight gain through physical exercises and a healthy life style between group 1 and group 2. Group 1. Students attending physical education classes (2 h/week), (Fig 3), answered yes – 275 (48.33%), and no - 294 (51.67%). There are no significant differences in the number of training sessions and physical exercises between the participants who said YES and those who said NO. Group 2 (sportive students). There are significant differences in preventing weight gain by physical exercises and a healthy lifestyle between the participants who said YES - 42 (79.25%) - and those who said NO – 11 (20.27%) of the 53 participants.

When asked if they ate low-calorie food or ate less to avoid weight gain (Fig 4), the participants who answered YES were much more than those who answered NO (59.23% sportive students, 62.26% non-sportive students). The difference is not statistically significant ($P=0.186$). Our data show that the participants in the study prefer eating less than doing physical exercises.

All participants in the study (100%) attend the physical education classes (Fig 5). Attendance is compulsory even for students with medical exemption who take part in recovery programmes.

The percentage of the option "To lose weight" (Fig.6) is high in both groups: group 1 (48.33%), group 2 (26.42%). The big difference between the two groups is due to the fact that sportive students have large muscle mass and optimal and stable body weight, while the non-sportive students who attend the physical education classes have low muscle mass and much adipose tissue.

In the past 7 days, the participants were physically active 60 minutes/day for 4 days in both groups. The percentage is higher for group 2 (sportive students) since they train for the sport they practise and play in the university teams (Fig.7).

In a regular week, the participants were physically active 60 minutes/day for: (Fig 8). The mean is 4-5 days a week as well.

Conclusions

The optimum level of physical education for a healthy life can be reached only by regular physical activity. Moderate and intense physical activity is good for health. Participants in group 2 who are used to sports practising have higher self-esteem, are used to train longer hours and have a moderate diet. Participants who do not practice any sports (group 1) or any physical activity except the physical education classes have become used to this lifestyle and make no effort to improve it. A healthy diet, without calories in excess and regular physical activity are essential for the prevention of overweight and obesity (8-12).

Questionnaire

This questionnaire is part of a study on the behavior of medical students from Timisoara. The study is realized by the "Victor Babes" University of Medicine and Pharmacy Timisoara. You are one of about .....students participating in this study. The questionnaire is anonymous. Your answers are confidential and will never be associated with you or the class you belong. We hope that you can answer all the questions. The success of the study depends on the honesty of your answers. You are not in front of a test. There are no correct or incorrect answers. Please mark the right answer to each question by circling the appropriate number or letter. If you do not find an answer that fits exactly, mark the one nearest to it. If you feel that you can not give an honest answer, we prefer that you not encircle the numbers or letters. If you have any question, raise your hand and the research assistant will help you.

Age.....years;
Sex: 1) Male 0)Female
Height.....cm;
Weight.....kg;

1.How do you find your weight?

a) Much below the normal weight
b) A little below the normal weight
c) About normal weight
d) A little over normal weight
e) Much above the normal weight

2.In the last 30 days, did you exercise to lose weight or to avoid gaining weight?

0)Yes
1)No

3) In the last 30 days, did you ate less or have consumed food lower in calories and fat to lose weight or prevent weight gain?

0)Yes
1)No

4.In the last 30 days, did you not eat for 24 hours or more to prevent weight gain or to lose weight?

0)Yes
1)No

5.In the last 30 days, did you take pills, powder or teas for weight loss without medical approval?

0)Yes
1)No

6.In the last 30 days did you intentionally caused vomiting or take laxatives to lose weight or maintain your current weight?

0)Yeas
1)No

7. What action on your weight you want to enterprise in the near future?

a) To lose weight
b) To gain weight
c) Keep my current weight
d) Do nothing

8. In a typical day during the semester (excluding weekends), how many hours do you watch TV / video DVD?

0) I do not watch TV/video
1) Less than an hour
2) 1 hour
3) 2 hours
4) 3 hours
5) 4 hours
6) 5 hours
7) 6 hours
8) 7 or more hours

9. On Saturdays and Sundays, how many hours do you watch TV / video DVD?

0) I do not watch TV/video
1) Less than an hour
2) 1 hour
3) 2 hours
4) 3 hours
5) 4 hours
6) 5 hours
7) 6 hours
8) 7 or more hours

10. In a typical day during the semester, how many hours do you work on the computer (to surf the web, chat with friends, play games, e-mail)?

0) I do not work on the PC
1) Less than an hour
2) 1 hour
3) 2 hours
4) 3 hours
5) 4 hours
6) 5 hours
7) 6 hours
8) 7 or more hours

11. On Saturdays and Sundays, how many hours do you work on the computer (to surf the web, chat with friends, play games, e-mail)?

0) I do not work on the PC
1) Less than an hour
2) 1 hour
3) 2 hours
4) 3 hours
5) 4 hours
6) 5 hours
7) 6 hours
8) 7 or more hours

12. *In a typical day during the semester, how much do you study at home?*

0) I do not study during the semester
1) Less than an hour
2) 1 hour
3) 2 hours
4) 3 hours
5) 4 hours
6) 5 hours
7) 6 hours
8) 7 or more hours

13. On Saturdays and Sundays, how much do you study at home?

0) I do not study on Saturdays and Sundays
1) Less than an hour
2) 1 hour
3) 2 hours
4) 3 hours
5) 4 hours
6) 5 hours
7) 6 hours
8) 7 or more hours

14. Do you participate in physical education classes?

0) Yes
1) No, I have medical exemption

15. In the last 7 days, on how many days were you physically active for a total time of at least 60 minutes a day?

7) Not a day
6) A day
5) 2 days
4) 3 days
3) 4 days
2) 5 days
1) 6 days
0) 7 days

16. In a typical week, how many days are you physically active for a total time of at least 60 minutes a day?

7) Not a day
6) A day
5) 2 days
4) 3 days
3) 4 days
2) 5 days
1) 6 days
0) 7 days

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Comparative effects of different concentrations of sorbitan monooleate on electromotive administration of diclofenac diethylamine in subjects with knee osteoarthritis

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Abstract. *Aim and scope*. The purpose of this study was to determine the effects of 2 different concentrations of sorbitan monooleate and methylated spirit as surfactants in the electromotive administration of diclofenac diethylamine among participants with knee osteoarthritis (OA). Materials and methods: Fifteen participants with knee OA were randomly allocated into 3 groups. Prior to diclofenac diethylamine iontophoresis, participants in group 1 had the stimulation electrode pads soaked in 1% w/v sorbitan monooleate and same procedures were adopted for those in group 2 and 3 but soaking and cleansing were in 0.5% w/v sorbitan monooleate and methylated spirit surfactants respectively. The data were analyzed using descriptive and inferential statistics. *Results*. There was significant reduction in pain intensity immediately after the first treatment session within group 1, ($p< 0.02$) and group 3, ($p<0.05$) but there was no significant difference in pain intensities of the subjects who received 0.5% sorbitan monooleate (group 2). Also, there was significant increase in knee flexion of group 1 participants after the first treatment session ($p< 0.006$). At 4th week, there was no significant difference in pain intensity and active knee flexion ROMs across the groups. *Conclusion*. The study concluded that there was no difference in the cumulative effects of 1%, 0.5%w/v sorbitan monooleate concentrations and methylated spirit as surfactants at the end of 4 weeks. However, 1% w/v of sorbitan monooleate concentration and methylated spirit enhanced reduction in pain intensity and increase in knee flexion at first treatment session.

***Key words**: diclofenac, sorbitan monooleate, iontophoresis, osteoarthritis.*

Introduction

Osteoarthritis (OA) is a disease characterized by degeneration of the hyaline cartilage and underlying bone within a joint as well as the presence of bony overgrowth (1).The chronic effect of OA is functional impairment in physical activities and this is as a result of cumulative pain, poor flexibility and decreased joint range of motion (2). Non-steroidal anti-inflammatory drugs (NSAIDS) are the mainstay in the management of OA because of the analgesic and anti-inflammatory properties[3]. However, these are associated with serious potential side effects, most especially, when there are co-morbid complications such as renal impairment and hypertension coupled with other gastrointestinal disorders (3, 4). Diclofenac causes gastric irritation and undergoes hepatic first-pass metabolism, and thus only 50% of the drug reaches the circulation (5).

Recent advances in medical practice necessitated finding techniques of how drugs may be effectively delivered to target tissues without complications. Iontophoresis remains one of the major mechanisms of enhancing drug flux through the skin (6, 7). The study of the penetration of drugs through the skin has become very important in recent years. The aims were to maximize the bioavailability of drugs, optimize

the therapeutic efficacy and minimize side effects (2). The transdermal route is considered along side with oral treatment as the most successful innovative research area in drug delivery, with around 40% of the drug delivery clinical evaluation studies related to the transdermal or the dermal system (8). It has been documented frequently that iontophoresis of ionized drug products provides a multiple fold increase in penetration over topical application (7).

Transdermal administration allows the drug to be introduced into the systemic circulation without initially entering the portal circulation where it may be metabolized into a pharmacologically inactive form (first pass effect), (9). Following drug administration, a delivery system is required to facilitate absorption because drugs cannot deliver themselves (10). During iontophoresis, the drug is delivered directly into the bloodstream without delay. Although, iontophoresis delivers less than a local injection, it provides much higher local concentration in the targeted tissue than oral administration (11).

Most NSAIDS inhibit inflammatory mediators by inhibiting cyclooxygenase enzymes, which reduces the production of precursors such as thromboxane, prostaglandin and leukotriene, and this subsequently terminating the inflammatory pathways (12). However, most of these drugs that are suitable for iontophoretic application do not achieve sufficiently high blood levels for pharmacological activity when administered transdermally, hence, it is sometimes necessary to enhance this delivery (13). This can be achieved by chemical means through the use of absorption promoters such as dimethylsulfoxide, azone, and surfactants (14).

Sorbitan monooleate is a non ionic surfactant and it is capable of lowering surface tension of a liquid and inter-facial tension between two liquids, or that between a liquid and a solid. Surfactants have also been used to augment physical penetration enhancement strategies for ultrasound and iontophoresis (15, 16). A surfactant can be classified by the presence of formally charged groups in its head; non ionic surfactant (has no charged group on its head) and ionic surfactant (has a net charge on its head). A non-ionic surfactant will likely not compete with either the positive or negative charge; hence, it prevents ionic competition during iontophoresis.

There are limited reports on the effectiveness of diclofenac in relieving pain arising from knee OA (17). Diclofenac has reduced solubility and in order to obtain further enhancement of skin permeation, the effects of micro-emulsions is required as a vehicle to drive it (18). Also, it appears there is still inadequacy in the concentrations of topical NSAIDS being delivered judging from persistence of pain and stiffness which subjects with OA still experience despite physiotherapy management. This may be attributed to the difficulty associated with delivering the drug molecules through the skin in sufficient quantities to exert pharmacologic and therapeutic effects. Chemical penetration enhancers may be required to reversibly lower the skin barrier through lipid disruption, increasing corneocyte permeability, and promoting partitioning of the drug into the tissue (19). It is generally believed that clinical efficacy in OA requires absorption of the active ingredient, to penetrate in sufficient quantities into underlying inflamed synovium and synovial fluid. Pain and functional ability remain indicators for interpreting therapeutic efficacy (20).

Iontophoresis is the transdermal administration of medicinal ions or bioactive agents using an electromotive force generated from the application of electric current (galvanic current). Many studies have been done to establish the efficacy of iontophoresis as an enhancer of drug penetration into tissues, little has been done on the effect of nonionic surfactant as an enhancer for diclofenac iontophoresis in improving treatment efficacy in OA. The primary aim of this study was to compare the effects different concentrations of sorbitan monooleate and methylated spirit as surfactants on application of diclofenac iontophoresis among subjects with knee osteoarthritis.

Material and Method

The participants comprised of 18 out-patients (6 males and 12 females) with symptomatic and radiological evidence of knee osteoarthritis who were receiving treatment in the department of physiotherapy at Obafemi Awolowo University Teaching Hospitals Complex (OAUTHC), Ile-Ife Osun state at the time of this study.

Inclusion criteria were: symptomatic and radiological evidence of osteoarthritis of the knee with Grade III OA (21), stable regimen of same medication (diclofenac tablet, 25mg once daily for the first one week only and it must be taken with food). They were all placed on diclofenac by an orthopeadic specialist. The duration of onset of the OA was less than 3 months. Other inclusive

criteria were absence of previous history traumatic episode to the musculoskeletal systems of the affected lower extremities and the age range of participants must be between 55 and 70 years of age. They were not on any form of antibiotics. Participants who were hypertensive were excluded because of the lowering effect of diclofenac on anti-hypertensive medications.

Patients with skin damage due to ionizing radiation; and with metallic implants were excluded because these constitute absolute contra-indications to electrical stimulation. The patients recruited for the study met all the inclusive criteria. The study was a pretest and post-test experimental design. The subjects were randomly allocated through balloting into 3 groups.

The instruments utilized for this study are: a 10 point semantic pain differential scale to rate the pain intensity, methylated spirit was used as surfactant for the third group and goniometer was utilized to measure the active knee flexion range of motion. Electrical muscle stimulator (Sonoplus 692 ref- 1600945) was used to deliver galvanic current, bicycle ergometer for exercise therapy while finger-tip unit (FTU) was used to quantify the amount of gel, using 2FTU which is equivalent to 1gram (22).

The sorbitan monooleate was produced by two pharmaceutical experts who were co-researchers in this study. Dispersion of span 80 was made in distilled water by first dispersing the span 80 in ethanol. Distilled water was added to 100% making a total of 200ml of solution containing either 0.5% w/v or 1% w/v of span 80.

The research and ethics committee of Obafemi Awolowo University Teaching Hospital Complex (OAUTHC) approved the study. The purpose and procedures of the research were explained to each of the participants prior to the commencement of data collection and they voluntarily consented to participate through written informed consent. The written consent contained information on the purposes of the study, the instruments used and details of the study. It was also stated that if participants experienced discomfort during application of the procedure, the treatment will be terminated. They were informed that information obtained will be mainly for research purposes. The Helsinki declaration on participants' right of making decision to voluntarily participate was taken into consideration while the beneficial effects from procedure were of priorities.

Subjects were randomly allocated into 3 groups through balloting with 6 participants in each group. The first group (comprising 3 male and female each) received diclofenac iontophoresis (2 FTU, an equivalence of 1g). The treatment skin area prior to application of diclofenac iontophoresis was cleansed with 2ml of 1% w/v sorbitan monooleate concentration. Also, the two electrodes were wrapped in guaze and soaked in the 1% w/v sorbitan monooleate. 1g (2 FTU) of diclofenac diethylamine gel (a negatively charged drug) was applied to the negatively charged electrode (cathode). The anode and cathode electrodes were fastened to the medial and lateral borders of the knee joint respectively using a Velcro strap.

The same procedure was adopted for the second group (1 male and 5 female) but the treatment skin area was cleansed with 2ml of 0.5% w/v sorbitan monooleate concentration and the electrodes were equally soaked in the same concentration (0.5% w/v).

The third group comprised of 2 male and 4 female, received diclofenac iontophoresis (1g) but prior to this, the skin treatment area was cleansed with 2ml of methylated spirit and the electrodes were soaked in methylated solution. The methylated spirit is the standard cleansing agent commonly used in most Nigerian clinics to lower skin resistance prior to injection or electrical stimulation.

Galvanic current was used on all subjects with the intensity gradually increased and maintained at the patient's threshold for 15 minutes (13,17). The electrical stimulator was preset to negative polarity and the current was modulated to 5mA. The surface area of the electrode was 10.89cm^2. This was used to compute the current density of 0.46mA/cm^2. All procedures were done with patient lying supine with a pillow under the knee, well positioned and relaxed for easy access to the affected knee joints. All the groups had baseline treatment programmes in the form of diclofenac iontophoresis and exercise therapy (bicycle ergometry) for 15 minutes. Each patient was treated two times a week for a period of 4 weeks. The knee joint range of motions (ROM) and pain intensities were assessed before and after every treatment session. A physiotherapist with 22 years clinical experience in musculoskeletal dysfunctions who was blinded to the purpose of the study rated the pre and post interventions ranges of motions and pain intensities throughout the study to avoid inter-rater variations.

Throughout the periods of interventions, participants were instructed to report any reaction,

most especially, gastrointestinal disorders (signs of ulcerations, abdominal pain, cramping and gastritis) and nausea.

Data analysis. Descriptive statistics was used to determine the mean and standard deviation of the ages, pain intensity and knee flexion range of motion (ROM). Analysis of Variance was used to compare the knee joint ROMs across the three groups, while Kruska-Wallis test was used to compare the pain intensity of the three groups. Paired t-test (dependent) was used to compare the pre and post treatment knee joint ROM at the first treatment session. Also, chi-square test (2 related samples) was used to compare the pre and post treatment pain intensity at the first treatment session. The level of significance was set at 0.05.

Results

The study suffered attrition mid-way into the study, 1male and 2 female patients were dropped from group 2 and 3 respectively making the total number of participants who completed the study to be 15. There reason was that being government workers, they were only permitted to attend clinics once in a week; and the frequency of this study was twice a week. There data were not included in the data analyzed.

The mean age of participants in the first group on which 1% w/v sorbitan monooleate was applied was 65.00 ± 15.41 years while it was 63.00 ± 7.18 years for the group with 0.5% w/v sorbitan monooleate but that of the 3rd group was 54.50 ± 4.20 years. The initial mean pain intensity (pre-intervention) for 1% w/v sorbitan monooleate group was 4.67 ± 1.03 while post intervention, was 3.50 ± 0.84, on a 10-point pain rating scale. The result of the chi-square test (2 related samples) showed that there was significant difference in the pre and post pain intensities (X^2= -2.33, P< 0.02) while for the 0.5% w/v sorbitan monooleate group, **t**he result of the chi-square test (2 related samples) showed that there was no significant difference in the pre and post pain intensities. The result of the chi-square test (2 related samples) showed that there was significant difference in the pre and post intervention pain intensities in the methyl salicylate group (X^2= -2.00, p<0.05), (Table I).

For the 1% w/v sorbitan monooleate group, the initial mean active knee flexion prior to intervention was 44.75º ± 12.54º while post intervention it was 50.83º ± 11.58º.

The result of the paired t-test showed that there was significant difference in the pre and post intervention knee flexion (ROM), (t= -4.48, p< 0.006). However, there were no significant differences in knee pre and post interventions knee flexion for the 0.5 % w/v sorbitan monooleate and methyl salicilate groups (Table II).

Table I. Comparison of pre and post intervention pain intensities at the first treatment session

Groups*	**Interventions**	**Pain intensity**		**X^2**	**p**
		Mean	**SD**		
Group 1	Pre	4.67	1.03		
	Post	3.50	0.84	-2.30	0.02
Group 2	Pre	3.80	1.30		
	Post	3.20	1.30	-1.73	0.08
Group 3	Pre	3.75	0.96		
	Post	3.25	0.96	-2.00	0.05

*group 1 - 1% w/v sorbitan monooleate, group 2 - 0.5% w/v sorbitan monooleate, group 3 - methylated spirit

At the end of the 4th week, the final mean pain intensity of the 1% w/v concentration of sorbitan monooleate group was 2.17 ± 0.75, on a 10-point pain rating scale while that of the 0.5% w/v concentration of sorbitan monooleate group was 2.40 ± 0.89 on a 10-point pain rating scale. Similarly, the final mean pain intensity of the methylated spirit group was 2.00±1.41, on a 10-point pain rating scale (Table III).

The result of the kruska-wallis test across the groups showed that there was no significant difference in initial pain intensities across the groups (X^2=2.38, p=0.30).

Similarly, there was no significant difference in final pain intensities across the groups (X^2=0.80, p=0.67), (Table III).

Table II. Comparison of active knee flexion before and immediately after first intervention

Groups*	Interventions	Active knee flexion (ROM)		X^2	p
		Mean	SD		
Group 1	Pre	44.75^0	12.54^0	-4.84	
	Post	50.83^0	11.58^0		0.006
Group 2	Pre	55.60^0	6.84^0		
	Post	57.60^0	7.95^0	-2.39	0.07
Group 3	Pre	56.25^0	10.30^0		
	Post	56.75^0	9.60^0	-1.00	0.39

*group 1 - 1% w/v sorbitan monooleate, group 2 - 0.5% w/v sorbitan monooleate, group 3 - methylated spirit

The final mean active knee flexion ROM for the 1% w/v sorbitan monooleate group at the fourth week of treatment was 56.50º ± 9.65º while the final mean active knee flexion for the 0.5% w/v sorbitan monooleate group was 61.40º ± 8.08º. The final mean knee flexion for the methylated spirit group was 60.25º ± 11.17º (Table IV). The result of the ANOVA showed that there was no significant difference in the initial active knee flexion ROM between the groups. Also, there was no significant difference in the final knee joint ROM at the fourth week between the groups (Table 4).

Table III. Comparison of pain intensities of the groups after 4 weeks

Groups	Intervention Stages	Pain intensity		X^2	p
		Mean	SD		
1	Initial	4.67	1.03		
2	Initial	3.80	1.30		
3	Initial	3.75	0.96	2.38	0.30
1	Final	2.17	0.75		
2	Final	2.40	0.89		
3	Final	2.00	1.41	0.80	0.67

Table IV. Comparison of active knee joint flexion of the groups after 4 weeks

Groups	Intervention Stages	Active knee flexion (ROM)		X^2	p
		Mean	SD		
1	Initial	44.75^0	12.54^0		
2	Initial	55.60^0	6.84^0		
3	Initial	56.25^0	10.30^0	2.07	0.17
1	Final	56.50^0	9.65^0		
2	Final	61.40^0	8.08^0		
3	Final	60.25^0	11.17^0	0.35	0.68

Discussion

The pathways for molecular transport in iontophoresis are through the intercellular (between the comeocytes); the transcellular (through cells) and appendageal (through the hair follicles, sweat ducts, secretary glands) and are described as paracellular, intracellular and shunt pathway respectively (6, 23, 24). Overcoming the protective barrier of the stratum corneum poses a challenge to transdermal drug delivery and this may prompt the use of chemical enhancers. Chemical penetration enhancers such as surfactants may enhance transdermal transportation of active ingredients through the skin (19). Lavon et al reported that surfactants have been used to augment physical penetration enhancement strategies via use of electromotive force (ultrasound and iontophoresis) (15).

This study was designed primarily to compare the effects of different concentrations of sorbitan monooleate and methylated spirit on administration of diclofenac iontophoresis in patients with knee osteoarthritis. The result of this study showed that there was significant reduction in pain intensity after the first treatment session in the subjects whose electrodes were soaked in 1% sorbitan monooleate and methylated spirit, but there was no significant difference in that of the subjects with 0.5% sorbitan monooleate. The reduced pain intensities observed in 1% sorbitan monooleate and methylated spirit groups was an indication that there was diclofenac flux into the tissues for therapeutic purposes. Kamal et al in an experimental study using skin of guinea pig noted that all microemulsion formulations tested including sorbitan monooleate increased diclofenac flux in the skin tissue (18). In another study, Biswajit et al, explained the mechanism of penetration enhancement effects, although, on another class of sorbitan (monolaurate 20); to be

due to the promotion of membrane-vehicle partitioning tendency of diclofenac (25). Also, there was significant increase in active knee flexion of group 1 participants after the first treatment session only. However, at the fourth week of treatment, there were no significant differences in pain intensity and knee flexion across the groups. This finding is suggests that all the surfactants enhance the fluxing of diclofenac through electromotive administration over a period of 4 weeks since clinical efficacy in OA is usually based on pain reduction and improvement in function. These findings are comparable to Iti et al reports. In an extensive study on the effect of surfactants as penetration enhancers in transdermal drug delivery Iti et al reported that diclofenac flux from the gel containing sorbitan monooleate was more than 10 times larger, although, it was in comparison with the use of tween 80 as surfactant (26).

The limitation of this study was that we were unable to determine the concentration of diclofenac diethylamine within the tissue, and the sample size was also relatively small, limiting generalization of the findings. Permeation was only based on the ability of the drug to exert therapeutic effects by increasing active knee flexion range of motion and alleviating pain. Because of the small sample, the findings were taken to be a preliminary technical report. We recommend that future studies should use a larger sample size. Also, future studies should use chromatography assays to determine the concentration of diclofenac diethylamine within the tissue.

Conclusion

We concluded that cumulative use of 1%, 0.5%w/v sorbitan monooleate and methylated spirit for 4 weeks had similar effects in enhancing transdermal application of diclofenac diethylamine iontophoresis in subjects with knee osteoarthritis. It was also concluded that 1% w/v sorbitan monooleate had significant acute effect in increasing active knee flexion and alleviating pain experienced by subjects with knee OA in a single session.

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The effect of hip abductors strengthening exercise on knee pain and function in people with knee osteoarthritis

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Abstract. *Objective*. This research is a step put forth for the further progression in this field, to find out the effectiveness of hip abductor muscles strengthening exercises along with the quadriceps exercises, in reducing knee pain and improving the functional performance of knee joint in patients with knee osteoarthritis. *Material and Method*. 30 subjects with knee osteoarthritis were divided into two groups randomly. Group A was provided with general quadriceps strengthening exercises along with short wave diathermy. While Group B was provided with quadriceps strengthening and hip abductors strengthening exercises in conjunction with SWD. Then both the groups were tested by using the following four scales: 11 Point Numeric Rating Scale, WOMAC Scale, Step Test and Timed Up and Go Test. *Results*. After providing the physiotherapy management to the patients both the groups showed significant improvement in all the four scales, 11 Point Numeric Rating Scale, WOMAC Scale, Step test and Timed Up and Go Test. But the group with hip abductor strengthening showed greater improvement than the other group.
Key words: *strengthening exercises, musculoskeletal pain, physical disability*.

Introduction

Osteoarthritis (OA) is a chronic localized joint disease and a leading cause of musculoskeletal pain and disability. Osteoarthritis disease process involves the whole joint including cartilage bone ligament and muscle with changes such as joint space narrowing, bony osteophytes and sclerosis on X-ray (1).

Osteoarthritis is the most common disease of joints in adults around the world. About one-third of all adults have radiological signs of osteoarthritis, although clinically significant osteoarthritis of the knee, hand, or hip in only 8.9% of the adult population. Knee osteoarthritis is the most common type (6% of all adults). The likelihood of developing osteoarthritis increases with age. The prevalence of osteoarthritis of the knee is higher among 70- to 74-year-old, rising as high as 40% (2).

In addition to age, a number of other risk factors have been identified, including major joint trauma, repetitive stress, overload of the joint, obesity, female gender, genetic factors, congenital/developmental defects, quadriceps weakness, inflammatory joint disease and several metabolic/endocrine disorders (3).

The quadriceps weakness, commonly associated with osteoarthritis of the knee, is widely believed to result from disuse atrophy secondary to pain in the involved joint. However, quadriceps weakness may be an etiologic factor in the development of osteoarthritis (4).

The primary treatment goals for OA are to reduce and control pain, improve function, improve or maintain joint mobility, and reduce or prevent physical disability (5).

Weight loss with exercise and dietary modifications may lessen the direct loads involving the affected joints, with the hip and knee in particular.

Physical therapy should focus on stretching and strengthening of all muscles that cross the affected joint i.e. quadriceps and hamstrings (6). Appropriate shoe wear and bracing (i.e. unloader knee braces) may also be an option in the early course of disease (7).

The application of superficial heat or cold is very common, often self-initiated, and is considered a component of a “first-line” intervention in the management of knee pain in older adults that the use of superficial heat or cold in conjunction with diathermy, trans-cutaneous electrical nerve stimulation (TENS) or ultrasound led to varying levels of symptom relief and functional improvements in patients with knee OA (8).

Several pharmacologic treatment regimens are associated with symptom relief, specifically, nonsteroidal anti-inflammatory drugs (NSAIDs), acetaminophen, cyclooxygenase-2 (COX-2) inhibitors, glucosamines, and corticosteroids have all been reported to have some beneficial effect (9).

Henrik Rogind, Birgitte Bibow-Nielsen et al investigated that physical function was improved in patients with severe osteoarthritis of knees during and after quadriceps strengthening exercises (10).

Recent evidence, however suggest that hip abductor muscle strength may be important for reducing the knee adduction moment (11). Increased toe out angle and trunk lean toward the stance limb are two gait strategies adopted by individuals with knee OA that have been shown to reduce the knee adduction moment (12).

It is also postulated that the hip abductor muscles also may influence knee joint loading through their control of the pelvis in the frontal plane. Kim L Bennel and Michael A Hunt et al have proposed that during single- limb stance phase of gait, weakness of the stance – limb hip abductor muscles may lead to drop of pelvis toward the contralateral limb, shifting the body's center of mass away from the stance limb towards the swing side (11, 13, 15).

Studies investigating the effects of strengthening in patients with knee OA have generally focused on improving quadriceps strength.

However little attention has been paid to improving the strength of lower limb muscle groups such as hip abductors. Due to the lack of research investigating their efficacy, such exercises are not routinely prescribed for knee OA.

This research is the step put forth for the further progression in this field, to find out the effectiveness of hip abductor muscles strengthening exercises along with the quadriceps exercises, in reducing knee pain and improving the functional performance of knee joint in patients with knee osteoarthritis.

Material and Method

Design of this study was a randomised controlled trial. 30 subjects, with painful, radiographically confirmed, medial compartment knee OA, aged between 50-70 years, were selected in the study and divided into two groups of 15 individuals in each. Group A - general quadriceps exercises and short wave diathermy (SWD); Group B - Hip abductors strengthening exercises, General quadriceps exercises and SWD.

After taking the consent from each individual the patients were randomly assigned into two groups- Group A and Group B, of 15 patients in each. The patients were then explained about the full procedure of the therapeutic process in detail and each exercise was taught to the patient accurately.

Firstly SWD was given to the patients for 15 minutes in supine lying position and knees in fully extended position. After treatment with SWD patients performed exercises, each exercise was performed in 3 sets of 10 repetitions.

The patients of Group A initially performed the exercises against gravity. After 2 weeks of the treatment protocol, a resistance of half kg weight was given to the patient by using weight cuff of half kg applied on distal end of the leg i.e. just proximal to ankle joint. Again at the 4th week half kg progression of the resistance was given to the patient, by using the weight cuff of 1 kg.

In Group A training protocols, the patients were instructed to perform the conventional static quadriceps, hamstring and gastrocnemius stretching exercise after each training session. All subjects were instructed to perform three repetitions of a 30 second static stretch of these muscle groups.

In Group B the patients were given the progression of resistance by weight cuff in the same manner as with the group A while in case of the exercises performed by the patient by using Thera bands as resistance. The patient initially used pink color band up to two weeks then progressed to purple color band till the fourth week and finally the light blue color band till 5th week.

After each training session the subjects were instructed to perform Quadriceps isometrics Hamstring and Hip abductor stretching with three repetitions of a 30 seconds static stretch.

Patients were trained five times per week for 5 a total time duration of 5 weeks. Each exercise session lasted for approximately 45 minutes. If patient felt pain while performing any of the exercises, it was stopped and started at the later stages.

*Exercise Programme for the Group A: q*uadriceps isometrics - 3 sets of 10 RM ; quadriceps stretch - 3 repetitions with 30 seconds hold; hamstring stretch - 3 repetitions with 30 seconds hold; calf stretch - 3 repetitions with 30 seconds hold; straight leg raising (SLR) in lying - 3 sets of 10 RM;

quadriceps short arc leg exercises - 3 sets of 10 RM; stationary bicycling- 5 min, after-wards increase the time limit

Exercise programme for the Group B: quads isometrics - 3 sets of 10 RM; SLR in lying - 3 sets of 10 RM; stretching of hamstrings - 3 repetitions with 30 seconds hold; hip abductor stretching 3 repetitions with 30 seconds hold; hip abduction in side lying - 3 sets of 10 RM; hip abduction in standing 3 sets of 5 RM; standing wall isometrics hip abduction - 3 sets of 5 RM.

To find out the effectiveness of the therapy evaluation was done on the basis of the scores obtained in the following scales/tests: 11 Point Numeric Rating Scale, Western Ontario and McMaster Universities Arthritis (WOMAC) Scale, Step Test, Timed Up and Go Test.

This evaluation was performed on week 0, and week 5, in the 5 weeks study and the data was collected on the basis of the tests given above.

Results

Thirty subjects (N=30) were taken which were divided into two groups, Group A (n=15) and Group B (n=15).

A treatment protocol of five weeks was administered to both the groups and the two groups were evaluated at week 0, and week 5, on the basis of four different scales.

WOMAC Osteoarthritis Index (Fig. 1). The Mean of group A at 0 week is 63.7 and standard deviation at 0 week is 7.2.

While mean of group B at 0 week is 64.8 and standard deviation at 0 week is 5.9.

The mean value of group A at 5th week is 61.6 and standard deviation is 7.2. While mean value of group B at 5th week is 55.7 and standard deviation is 6.5. The t value by applying the independent t test is obtained as 2.336.

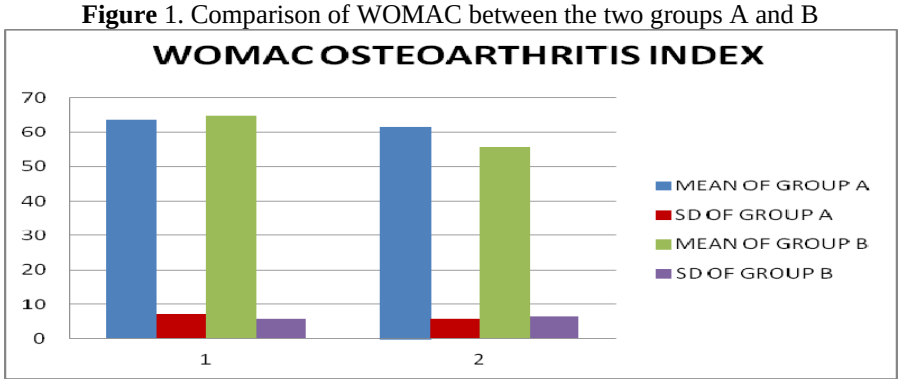
The p value obtained by the independent t test is 0.027 which is a significant value, when the level of significance is 0.05.

Table I. Comparison of WOMAC between two groups A and B

WOMAC	GROUP A N=15		GROUP B N=15		t VALUE	P VALUE
	MEAN	S.D.	MEAN	S.D.		
WOMAC 0	63.7	7.2	64.8	5.9	2.336	0.027 S
WOMAC 5	61.6	7.2	55.7	6.5		

WOMAC 0 = Score of WOMAC on 0 week; WOMAC 5= Score of WOMAC on 5th week;
SD= Standard Deviation; S= Significant

Figure 1. Comparison of WOMAC between the two groups A and B



11 Point Numeric Rating Scale (Fig. 2). The mean value obtained for group A at 0 week is 7.9 and standard deviation is 0.9. While the mean value for group B at 0 week is 7.9 and standard deviation at 0 week is 0.7. The mean value for group A at 5th week is 6.3 and standard deviation at 5th week is 1.3.

While the mean value for group B at 5th week is 4.8 and standard deviation for group B is 1.0.

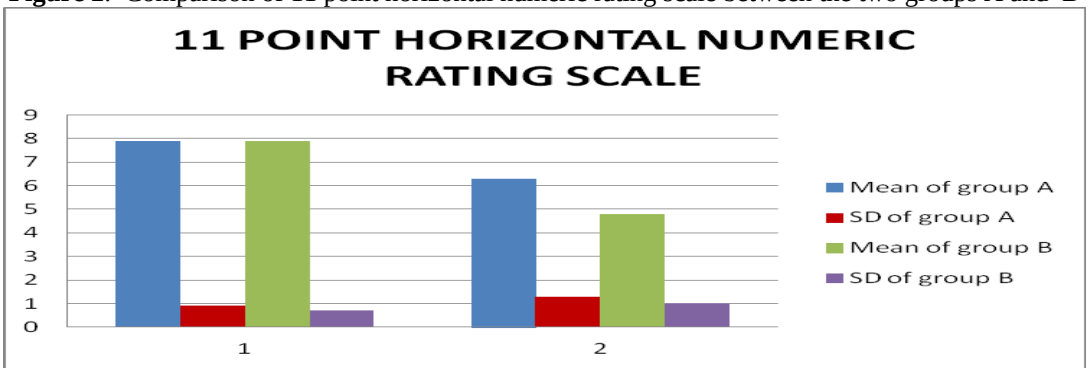
The t value obtained by independent t test is 3.44 and p value obtained in the independent t test is 0.002 which is a significant value when the level of significance is 0.01.

Table II. Comparison of 11 Point Horizontal Numeric Rating Scale between the two groups

NRS	GROUP A N=15		GROUP B N=15		t VALUE	P value
	MEAN	S.D.	MEAN	S.D.		
NRS 0	7.9	0.9	7.9	0.7	3.44	0.002 S
NRS 5	6.3	1.3	4.8	1.0		

NRS 0= Numeric Rating Scale on 0 week; NRS 5= Numeric Rating Scale on 5th week; SD= Standard Deviation; S = Significant

Figure 2. Comparison of 11 point horizontal numeric rating scale between the two groups A and B



Step Test (Fig. 3). The mean value obtained for group A at 0 week is 3.4 and standard deviation at 0 week is 0.9. While the mean value for group B at 0 week is 3.0 and standard deviation at 0 week is 0.8.

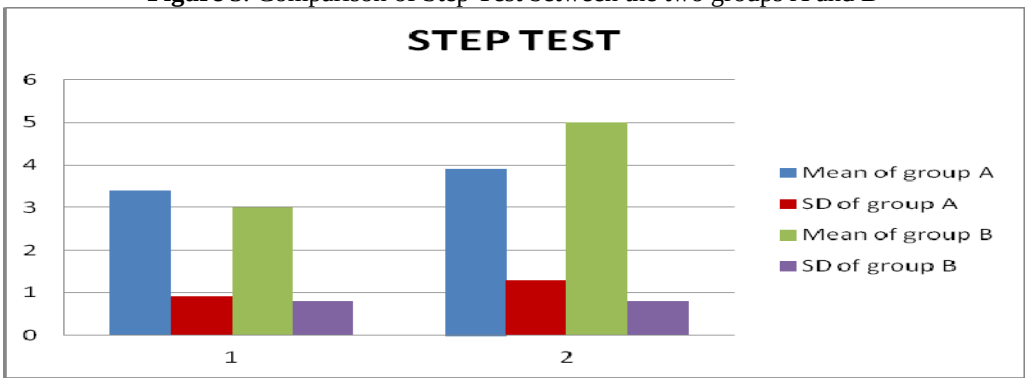
The mean value obtained for group A at 5th week is 3.9 and standard deviation at 5th week is 1.3. While the mean value for group B at 5th week is 5 and standard deviation of group B at 5th week is 0.8. By applying the independent sample t test the t value obtained is 2.78. The p value obtained in the independent sample t test is 0.01 which is a significant value and the level of significance is 0.01.

Table III. Comparison of Step Test between the two groups

STEP TEST	GROUP A N=15		GROUP B N=15		t VALUE	P value
	MEAN	S.D.	MEAN	S.D.		
ST 0	3.4	0.9	3.0	0.8	2.78	0.01 S
ST 5	3.9	1.3	5	0.8		

ST0 = Step Test on 0 week; ST5= Step Test on 5th week; SD = Standard Deviation
S= Significant

Figure 3. Comparison of Step Test between the two groups A and B



Timed Up and Go Test (Fig. 4). The mean value for group A at 0 week is 13.6 and standard deviation for group A at 0 week is 1.7. While mean value of group B at 0 week is 13.6 and standard deviation for group B at 0 week is 1.5. The mean value of group A at 5th week is 12.3 and standard deviation of group A at 5th week is 1.9. While mean value of group B at 5th week is 10.7 and standard deviation of group B at 5th week is 1.4.

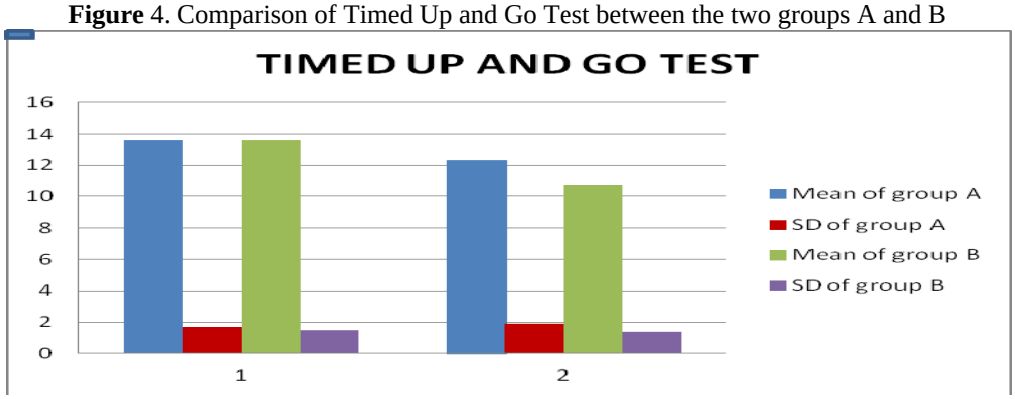
The t value calculated by independent sample t test is 2.62 and p value calculated by independent sample t test is 0.014 when the level of significance is 0.05.

Table IV. Comparison of Timed Up and Go Test between two groups

TUG	GROUP A N=15		GROUP B N=15		t VALUE	P value
	MEAN	S.D.	MEAN	S.D.		
TUG 0	13.6	1.7	13.6	1.5	2.62	0.014 S
TUG 5	12.3	1.9	10.7	1.4		

TUG 0= Timed Up and Go Test on 0 week; TUG 5 = Timed Up and Go Test on 5th week;
SD= Standard Deviation; S= Significant

Figure 4. Comparison of Timed Up and Go Test between the two groups A and B



Discussion

Primary goal of the study was to show that the Hip Abductors Strengthening along with the Quadriceps Strengthening is effective in improving disease associated symptoms namely, decreasing pain and improving functional performance in the subjects with knee osteoarthritis, who were selected on the basis of similar inclusion criterias.

The subjects collected for the thesis had the inclusion criterias (11) as: age limit 50-70 years; people reporting average knee pain on walking >3, on an 11 point scale (0= no pain, 10= maximal pain); predominant pain/tenderness over medial region of the knee; medial compartment radiographic OA defined as at least grade 1, medial joint space narrowing or grade 1 medial tibial or femoral osteophytes.

Lower limb muscle strengthening has recently received increased interest as an inexpensive treatment for knee OA due to its ability to reduce knee pain and improve physical function (11).

The novelty of the present study is the focus on hip abductor muscle strengthening along with quadriceps strengthening. The hip abductors play an important role in the stabilization of the pelvis and trunk.

According to Sled, Eluzio et al, during the single limb stance phase of gait, weakness of stance limb hip abductor muscle may lead to drop of pelvis towards the contralateral limb, shifting the body's center of mass away from the stance limb towards the swing side. These adjustments theoretically, could lead to higher the knee adduction moments and greater medial knee joint loading (12). Thus hip abductor muscle activity appears to be an important yet understudied contributor in the disease modifying effect in knee joint osteoarthritis.

In this study a series of seven exercises were given to strengthen the hip abductors and quadriceps, based on the ease to performance and isolation of the targeted musculature (10-12).

The overall result obtained from this study was based on the four tests WOMAC (15, 16), Step Test (17), Timed Up and Go Test (15) and 11 Point Numeric Rating Scale (18) showed that the patients when administered with hip abductors strengthening exercises along with the general quadriceps exercises, show much better improvement in pain and function as compared to the patients who were only administered with general quadriceps exercises.

The quadriceps weakness commonly associated with osteoarthritis of the knee is widely believed to result from disuse atrophy secondary to pain in the involved joint. However, quadriceps weakness may be an etiologic factor in the development of osteoarthritis (19).

So the patients of group A were provided with general quadriceps exercises. This group showed that the pain was decreased and functional performance was also increased to some extent this may be due to the fact that the quadriceps muscle were strengthened and they were able to support the knee joint adequately. As it is well known fact that weak or fatigued muscles cannot adequately support the knee joint or absorb shock before it gets to the knee and the extra stress placed upon the knee can cause injury to the structure of the knee strengthening exercises can make the muscles tight and the stretching exercise make the muscle flexible (20).

The patients of group B were provided with general quadriceps exercises along with the hip abductors strengthening exercises. The subjects who belonged to this group showed much better improvement than compared with the group A as the patients of this group were strengthened not only by the muscles around knee joint but also by the hip abductors which is helpful in stabilizing the pelvis during walking. It has been proposed that weakness of hip abductor muscles may lead to additional pelvic drop in the contralateral swing limb, which shifts the body's centre of mass towards the swing limb. This shift may have an influence on increased loading across the medial compartment of knee. Therefore, strengthening lower extremity muscles, focusing on hip abductors may be beneficial (15).

Lastly, objective and self- reported measurement of pain will provide clinically relevant estimates of change in knee OA symptoms with my novel hip strengthening intervention. Therefore this study will quantify the effects of hip strengthening on biomechanical, functional and clinical attributes of knee OA.

Thus the results from this study will contribute to evidence based recommendations for the usefulness of hip abductor muscle strengthening in the management of knee osteoarthritis.

Conclusion

Result of this study shows that the hip muscle strengthening along with quadriceps strengthening is effective in decreasing knee pain and improving function in people with knee osteoarthritis.

The study therefore concludes that the experimental hypothesis that is the hip muscle strengthening along with quadriceps strengthening is effective in decreasing knee pain and improving function in people with knee osteoarthritis, is accepted.

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Aerobic versus Anaerobic - comparative studies concerning the dynamics of the aerobic and anaerobic effort parameters in top athletes

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Abstract. This study was designed to bring new information about the hypothesis of "concurrent training" between strength and endurance which happened in high level training of elite athletes. We considered that the comparative study of the aerobic and anaerobic performance parameters of specifically trained athletes can offer practical information about these adaptation. For this purpose were analysed the results from 450 top athletes, trained in aerobic, anaerobic and mixed energogenesis sports activities, obtained during the assessment of the effort capacity. The results sustain that training a particular energetic pathway at high level can have negative or positive effects on the other one, based on the athlete`s gender. The excessive training of the aerobic effort capacity happen to the detriment of the anaerobic effort capacity for both, female and male athletes. The very high intensity, short duration training which characterizes the physical training in the alactic anaerobic trials corroborated with decreasing the maximum oxygen consumption only in the male anaerobic alactic group, while the female anaerobic groups, both alactic and lactic, registered positive correlations with the maximum oxygen consumption.
Key words: *effort capacity, training program, athletes, muscle fiber.*

Introduction

The strength and endurance "concurrent training" phenomenon has been described for the first time by Hickson in 1980 (1) and since then the researcher`s opinions have been divided into *pros* and *cons*. Knowledge about the way in which the development of an energetic system influences this phenomenon is very important both for creating the best training program and obtaining athletic performance.

It is well known that the study brings contributions for either proving or dismissing the concurrent training theory. Highlighting a correlation between the aerobic effort capacity and the different phases of the anaerobic effort (the alactacid and lactacid phases) must be important in creating the training program for predominantly anaerobic or aerobic energogenesis sport activities, but especially for mixed energogenesis sport activities.

A lot of studies demonstrated that specific training produces effects on the muscle fiber`s composition (2-6) dimension and conversion from one type to another (7-9).

We also considered that the comparative study of the aerobic and anaerobic performance parameters of specifically trained athletes can offer practical information about these adaptations; thus we have selected significant parameters and the testing protocols which allow such an analysis.

Many authors confirmed the utility of the Wingate test (10) as a protocol for the anaerobic effort capacity (11, 12). On the other hand, for over 40 years in Romania we have the experience of the protocol described by Szogy and Cherebetiu in 1974 (13) "The Total Work Performed Test" (TWPT). The differences from the Wingate Test (WT) are: longer duration for performing the standard effort (45 seconds); intervals at which the measurements are realized (5 and 30s for WT, and also 10, 20 and 45s, for TWPT); physical parameters assessed (Wingate Test measures Power, while Total Work Performed Test measures Total mechanical Work Performed in 10s, 20s and 45s from the effort's beginning - TWP).

We have considered that using both tests for investigating the anaerobic effort capacity could bring additional information, diminishing different aspects of the anaerobic effort capacity. In addition, the parallel study of both tests, WT and TWPT offers information about the intermediary phases of the anaerobic effort:

5s (Peak Power of WT), 10s and 20s (TWP on 10 and 20 seconds of TWPT), 30 seconds (Average Power of WT) and 45 seconds (TWP on 45s from TWPT). For these reasons, an eventual influence form the aerobic mechanisms on the anaerobic effort capacity are more likely to be observed.

The results of female training compared to the male training implies separated research about the effort adaptation for the two gender, doubly so as muscle composition for untrained women and men are different (4, 14, 15).

The main hypotheses of this study were:

- If the endurance adaptation to effort would influence negatively the anaerobic athlete`s qualities it should be that the high values of the maximum oxygen uptake to corroborate with the low values of the anaerobic alactic parameters (Peak Power of the Wingate test and TWP on 10 seconds from the Test of the Total Work Performed described by Szogy and Cherebetiu). Obviously, if a maximum oxygen uptake significantly contributes to the alactic anaerobic effort, then it would be logical to find positive correlations between these parameters.
- If the aerobic energy metabolism significantly superimposes over that of the anaerobic glycolysis, good maximum oxygen consumption should corroborate with the increased values of the glycolytic anaerobic performance, meaning of the Average Power (AP) from WT and TWP on 45 seconds from TWPT.

As a result a competitive relation between the aerobic and anaerobic glycolysis could be expressed as a negative correlation between the parameters of the two types of energogenesis.

Material and Method

The subjects. The Romanian National and Olympic teams are due to run biannual pre-participation examinations at the National Institute of Sports Medicine, Bucharest, Romania. This study analysed the results from 450 top athletes (throwing trials, jumping trials, 100m flat running, 400m flat running, 400m hurdles running, 800m flat running, 1500m flat running, marathon, march, but also football and handball players) obtained during the assessment of the effort capacity, between January 2008 – December 2010.

The subjects were accordingly divided to the specifics of the athletic trial, in four groups: *Group 1*: 162 athletes participating in anaerobic alactic athletic disciplines (100, 200 m sprints, 100 m hurdles, vertical jumps) - the female group contained 85 athletes (anaerobic alactic women's lot) and the male group contained 77 athletes (anaerobic alactic men's lot); *Group 2:* 62 athletes participating in anaerobic trials, but with an important lactic component - 400m sprints and 400m hurdles runners - the female group was made of 31 athletes (anaerobic lactic women's lot), and the male group contained 31 athletes (anaerobic lactic men's lot); *Group 3:* 156 athletes participating in sports with mixed energogenesis, aerobic and anaerobic: middle runners 800m and 1500m but also football and handball - the female group had 64 athletes (mixed women's lot), and the male group had 92 athletes (mixed men's lot); *Group 4:* 70 athletes participating in high endurance: marathon and race walk, of which 35 were women (aerobic women's lot) and 35 men (aerobic men's lot).

The testing protocol. The subjects were tested in order to investigate the aerobic and anaerobic effort capacity through the use of two tests which took place in the same day, but within a 30 minute interval between them. The first test was the Astrand- Rhyming test (16, 17) for the indirect determination of the maximum oxygen uptake. The second was a maximal test performed 45 seconds and whose results were interpreted both through the Wingate method and the total work performed method described by Szogy and Cherebetiu.

For testing the aerobic capacity through the indirect maximum oxygen uptake, the subjects constant pedaling for 6 minutes on a Monark bicycle ergometer. An individualised constant load was applied to the bicycle ergometer, for each athlete, according to the body weight (1,5 – 2w/Kg), gender, sport. After performing the test, the blood pressure and heart rate of the athletes were measured on clinostats, each minute until their parameters returned to the rest values. Between the 2 tests there was a 15-30 minute interval, in which the athlete received detailed explanations about the protocol of the following test.

The assessment of the anaerobic effort capacity was performed on a Monark 894-E, bicycle ergometer, wired to a computer using original, manufacturer-delivered software - Sports Medicine Industries, Inc. (SMI) (St. Cloud, MN) (Power software), software which can graphically represent the basic parameter of a Wingate testing: the power. The resistance applied to the bicycle ergometer was calculated for each subject

according to their body weight (kg multiplied with 7,5 %).
The data from each subject was introduced in the SMI Program software.
Before collecting the data, and before applying the break on the wheel, the athlete pedaled without resistance for a few seconds, trying to reach the maximum speed in order to overcome the wheel's inertia.
Right after that, the assistant released the break weight and the software started collecting the data. All the subjects pedaled as fast as they could over a time span of 45 seconds. The athlete was verbally encouraged during the entire testing and was told every 5 seconds the time left until the end of the effort.
Data analysis. In the present study, we looked at the relative values (kgm/kgc) obtained for both the Wingate Test (Peak Power - PP, Average Power - AP, Fatigue Index - FI) and the Total Work Performed parameters (TWP10'', TWP20'', TWP45'').
The statistical analysis was performed using the standard statistical analysis of the Microsoft Excel software and included: medium values, standard deviations and value intervals for the parameters measured.
The comparison between the levels of these parameters for each separate group was done using the Student test. The correlations between parameters were evaluated through the Pearson correlation method and the level of signification was considered at $p<0.05$.

Results

The sports mostly aerobic energogenesis obtained, for the maximum oxygen uptake (VO_2max, the highest values (for women, medium values of 62.75±12.14ml/kgc and for men values of 58.02±9.14ml/kgc), while the anaerobic alactic sports had the lowest values (women 48±9.01 and men 42.21±7.21ml/kgc).
The medium values for the athletic disciplines with mixed energogenesis were 52.09±8.92ml/kgc for women and 50.13±7.8ml/kgc for men, in addition the anaerobic lactic trials, the average values were 48.46±8.54 for women and 47.25±6.28 for men (Table I, Fig. 1).

Table I. The values of the maximum oxygen uptake (VO_2 max/Kg) in the research groups

	VO2max/kg							
	AEROBIC M	AEROBIC W	MIXT M	MIXT W	ANA LACT M	ANA LACT W	ANA ALACT M	ANA ALACT W
Mean	58.02	62.75	50.13	52.09	47.25	48.46	42.21	48.00
Standard deviation	9.14	12.14	7.81	8.92	6.28	8.54	7.21	9.01
Minimum	35.93	45.26	28.4	36.55	31.7	37.99	28.23	31.71
Maximum	77.44	97.34	72.41	76.6	64.26	69.43	56.12	68.85

M – male; W-women; ANA LACT- anaerobic lactic; ANA ALACT – anaerobic alactic

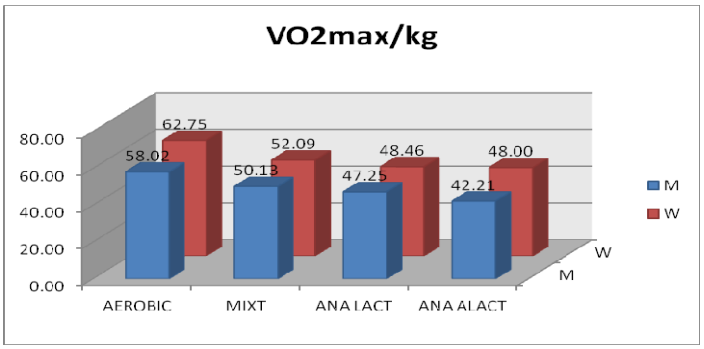

Figure 1. The values of the maximum oxygen uptake (VO_2 max/Kg) in the research groups

The average values obtained through Wingate test in this study for the anaerobic capacity (PP/kgc, AP/kgc, FI) compared with those declared by the authors of other studies which used the same load amount of 0.075 kp·kg^{-1} , Maud and Schultz [18] and Zupan [19] are listed in the following table II.

Table II. The values of the anaerobic capacity (comparison with other authors)

Comparation for PP, AP si FI values			
Men			
	PP/kg	AP/kg	FI
Maud si Schultz	9.18 ± 1.43	7.28 ± 0.88	37.67 ± 9.89
Zupan	9.59 ± 0.99	7.16 ± 0.7	42 ± 7.8
Curent study	9.8 ± 1.5	7.58 ± 0.36	53 ± 0.14
Women			
	PP/kg	AP/kg	FI
Maud si Schultz	7.61 ± 1.24	6.35 ± 0.73	35.0 5± 8.32
Zupan	9.59 ± 0.98	8.47 ± 0.88	47 ± 7.6
Curent study	7.9 ± 0.71	6.32 ± 0.22	47.67 ± 2.8

PP-PeakPower; AP - Average Power ; FI - Fatigue Index

The parameters recommended by the Wingate testing protocol (Pick Power – PP and Average Power – AP) (Table III-IV, Fig.3-4) and by Szogy and Cherebetiu (TWP at 10, 20 and 45 seconds) have been analysed separately, for each group and showed higher values for the athletes trained in anaerobic sports (Table V-VII, Fig.5-7). The groups with athletes trained for anaerobic alactic metabolism presented the highest values for the maximum and medium anaerobic power, but also for the work performed (TWP 10", TWP20", TWP45") in comparison to all the other athletes.

Table III. The values of the Pick Power in the research groups

	PP/kg							
	AEROBIC M	AEROBIC W	MIXT M	MIXT W	ANA LACT M	ANA LACT W	ANA ALACT M	ANA ALACT W
Mean	7.93	7.21	9.61	7.75	10.13	8.00	11.57	8.93
Standard deviation	1.69	0.94	1.57	1.21	1.68	1.00	1.96	1.48
Minimum	4.50	5.62	6.56	4.61	6.05	5.96	6.55	4.68
Maximum	10.79	8.92	16.40	10.66	14.34	9.69	18.05	12.20

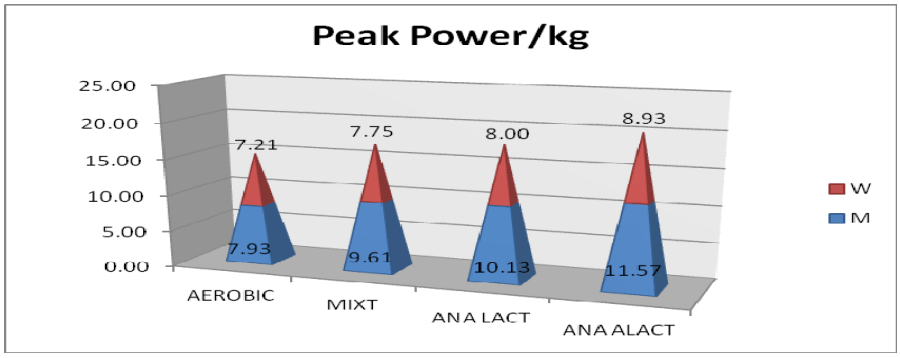

Figure 3. The values of the Pick Power in the research groups

Table IV. The values of the Average Power values

	AP 30/kg					
	AEROBIC M	AEROBIC W	MIXT M	MIXT W	ANA LACT M	ANA LACT W
Mean	7.23	5.71	7.55	6.20	7.96	6.58
Standard deviation	0.69	0.79	0.86	0.88	0.94	0.85
Minimum	5.87	3.79	5.17	3.43	5.12	4.55
Maximum	8.07	6.98	9.34	7.85	9.68	8.05

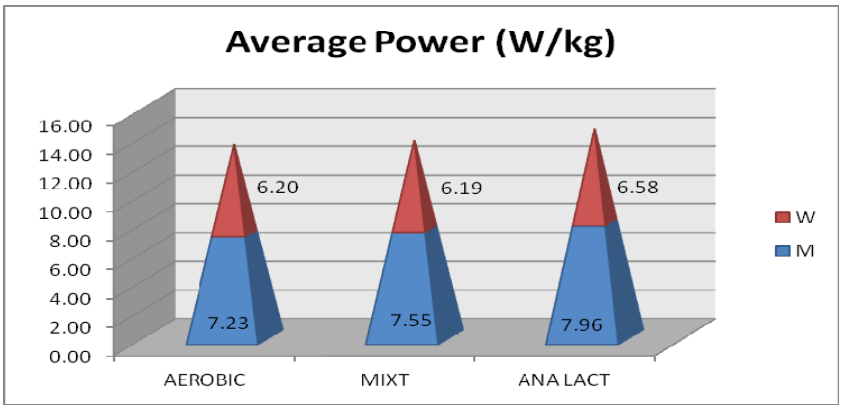

Figure 4. The values of the Average Power in the research groups

Table V. The values of the TWP10 values

	TWP10 (kgm/kg)							
	AEROBIC M	AEROBIC W	MIXT M	MIXT W	ANA LACT M	ANA LACT W	ANA ALACT M	ANA ALACT W
Mean	7.13	5.80	7.84	6.32	8.21	6.55	9.21	7.47
Standar deviation	0.90	0.78	1.39	1.08	1.44	0.98	1.47	1.38
Minimum	5.05	4.58	5.07	3.57	4.94	4.44	4.26	3.68
Maximum	8.77	7.64	12.12	8.58	11.63	8.34	12.95	10

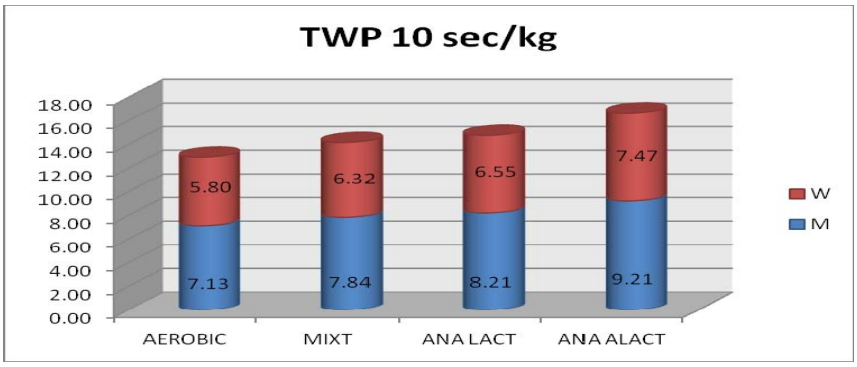

Figure 5. The values of the TWP10 values

Table VI. The values of the TWP20 values

	TWP20 (kgm/kg)					
	AEROBIC M	AEROBIC W	MIXT M	MIXT W	ANA LACT M	ANA LACT W
Mean	12.89	11.05	14.45	11.73	15.12	12.33
Standard deviation	1.60	1.61	2.03	1.83	2.06	1.67
Minimum	9.83	7.62	9.64	6.32	9.32	8.79
Maximum	15.37	14.03	19.62	15.44	19.83	15.26

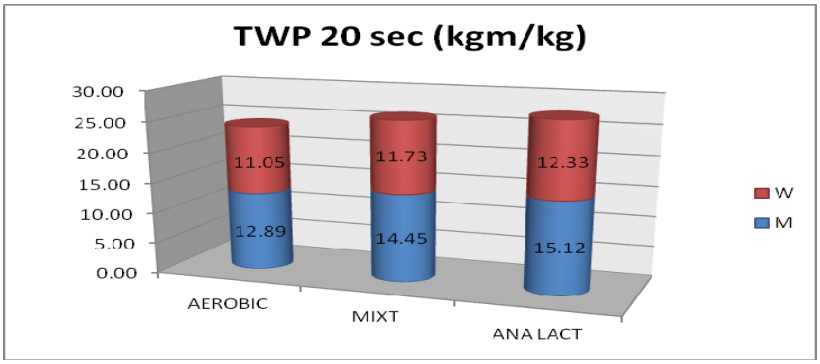

Figure 6. The values of the TWP20 values

Table VII. The values of the TWP45 values

	TWP45 (kgm/kg)					
	AEROBIC M	AEROBIC W	MIXT M	MIXT W	ANA LACT M	ANA LACT W
Mean	23.55	20.51	25.03	20.74	26.50	22.44
Standard deviation	2.30	2.40	2.60	2.71	2.37	2.69
Minimum	19.83	13.45	15.79	10.8	18.5	16.24
Maximum	26.89	25.12	29.94	25.68	30.1	26.72

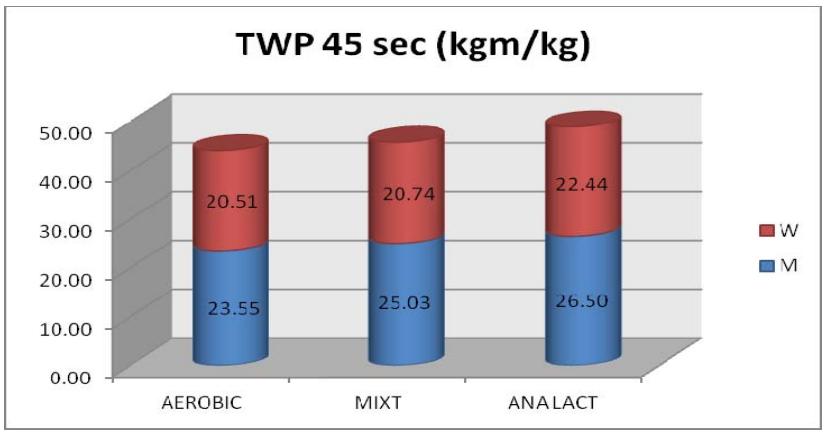

Figure 7. The values of the TWP45 values

When studying another parameter, the Time to reach Peak Power (TPP), delivered by the software of the Monark cycloergometer, it has been shown/indicated that only the groups with athletes trained for very short and high intensity (the anaerobic alactic female and male groups) obtained the Peak Power in the first 5 – second interval, the rest of the groups registering this parameter in the second 5 - second interval (Table VIII, Fig. 8). We also underline that this parameter measures (in milliseconds) the time being elapsed from the beginning of the effort to the moment when the curve of the muscle power developed by the athlete reaches the highest point.

Table VIII. The values of the Time at Pick Power in the research groups

	Time at Peak Power (msec)							
	AEROBIC M	AEROBIC W	MIXT M	MIXT W	ANA LACT M	ANA LACT W	ANA ALACT M	ANA ALACT W
Mean	5358	6940	6960	6413	5922	8598	3630	3960
Standard deviation	5773	6556	7940	7190	6542	6837	3333	2393
Minimum	1341	1040	21	1268	1114	1069	1034	1178
Maximum	35502	23119	40674	43669	31912	26601	15358	9555

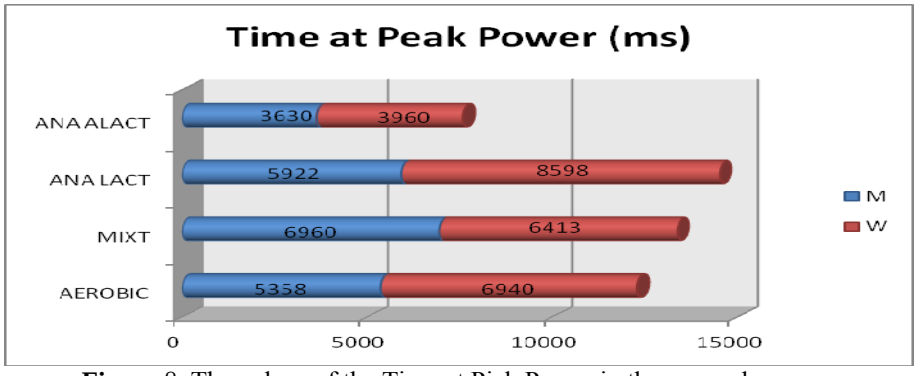

Figure 8. The values of the Time at Pick Power in the research groups

The statistical analysis showed a negative correlation between the maximum oxygen uptake and the anaerobic effort capacity parameters advanced by Szogy and Cherebetiu (total work performed) in the athletes trained for endurance, as shown in the graphics below (Fig 9 and 10):

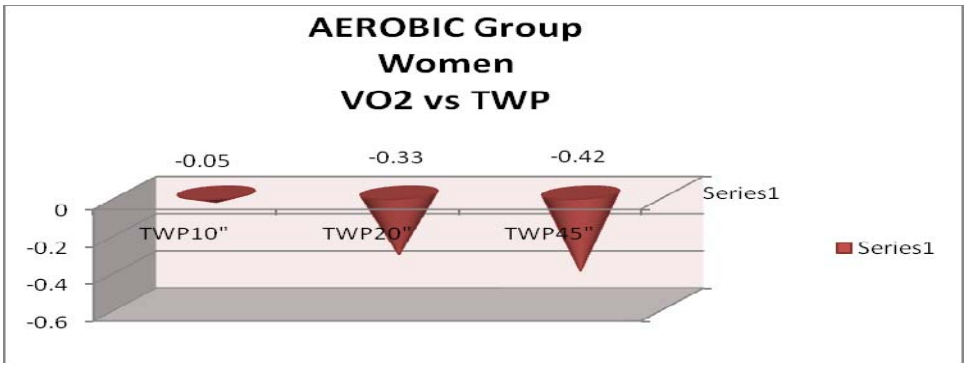

Figure 9. The correlation between VO_2max and TPW at aerobic women group

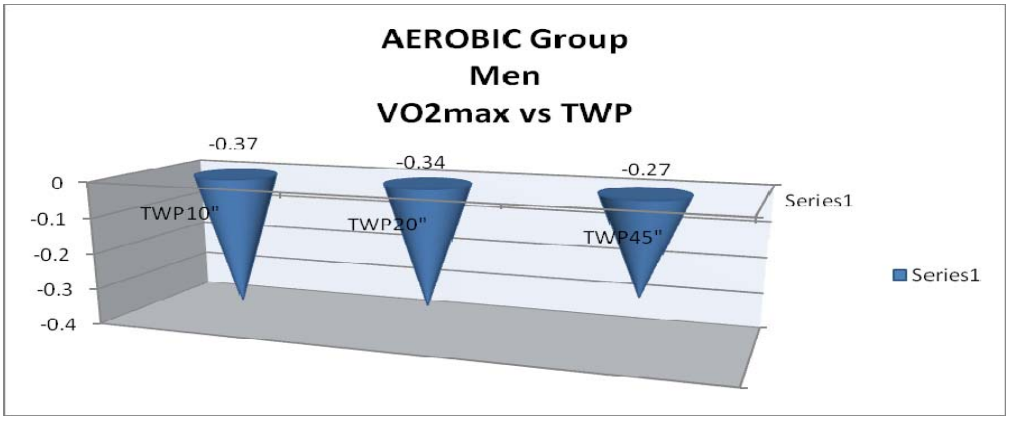

Figure 10. The correlation between VO_2max and TPW at aerobic male group

The correlation tendency remained when the VO_2max was compared with the anaerobic parameters advanced by the authors of the Test, but the correlation coefficient was significant only for VO_2max vs. Average Power in the feminine group (correlation coefficient – 0.35 and $p < 0.005$).

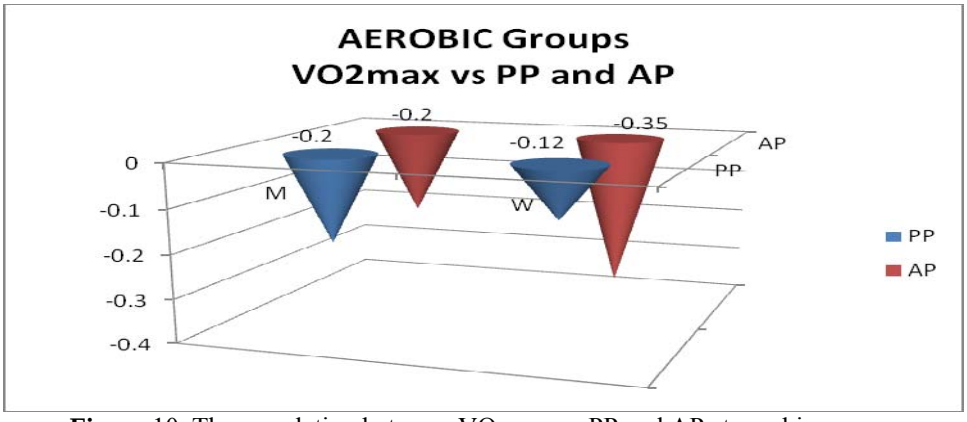

Figure 10. The correlation between VO_2max vs PP and AP at aerobic groups

This negative correlation between the maximum oxygen uptake, as parameter for the aerobic effort capacity and the anaerobic effort capacity parameters seem to confirm the hypothesis of a "concurrent training", and in this case the excessive training of the aerobic effort capacity

seems to happen to the detriment of the anaerobic effort capacity (to be discussed) (Fig. 11-12).
The feminine groups trained in athletic disciplines with mostly anaerobic component showed positive corroborations between the maximum oxygen uptake and the TWP10" and Peak Power parameters. Even more, the positive correlation was registered for all the anaerobic performance parameters (work performed and all powers), during the entire 45" duration of the maximal effort ($p<0.05$).

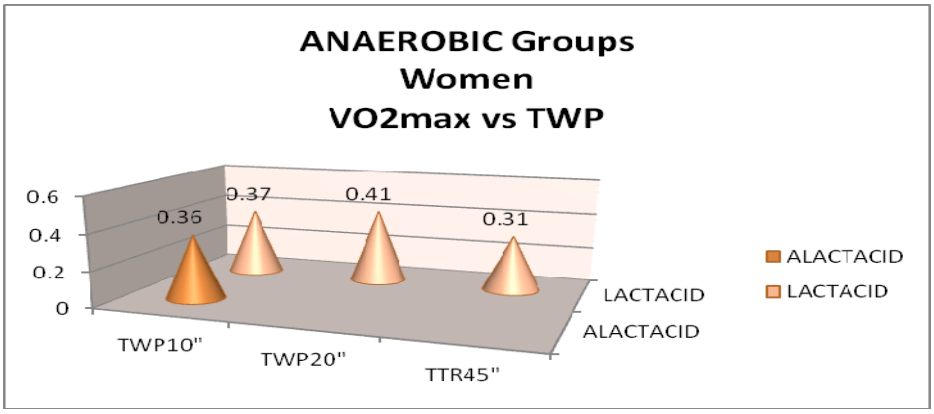

Figure 11. The correlation between VO_2max vs TWP at anaerobic group women

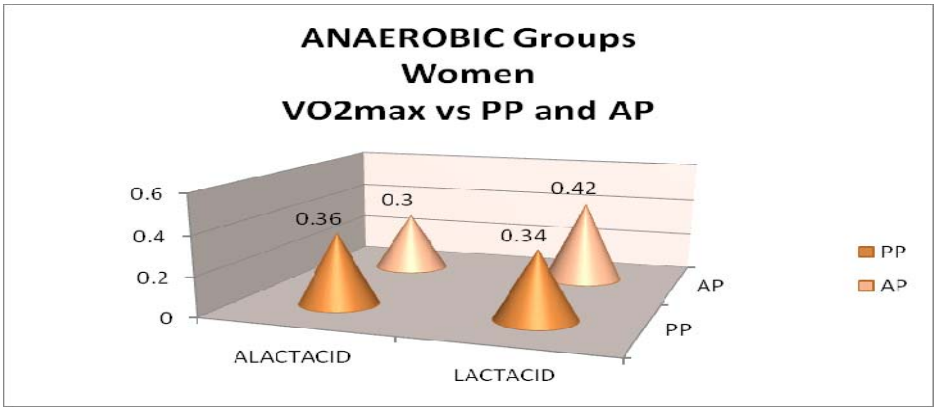

Figure 12. The correlation between VO_2max vs PP and AP at anaerobic group women

Alternatively, in the anaerobic alactic male group, the obtained correlation between the maximum oxygen uptake and the TWP on 10" was a negative one, which shows that, for this group, the intense anaerobic training corroborated with low values of the maximum oxygen uptake ($r= -0.33$, $p<0.05$) (Fig.12).

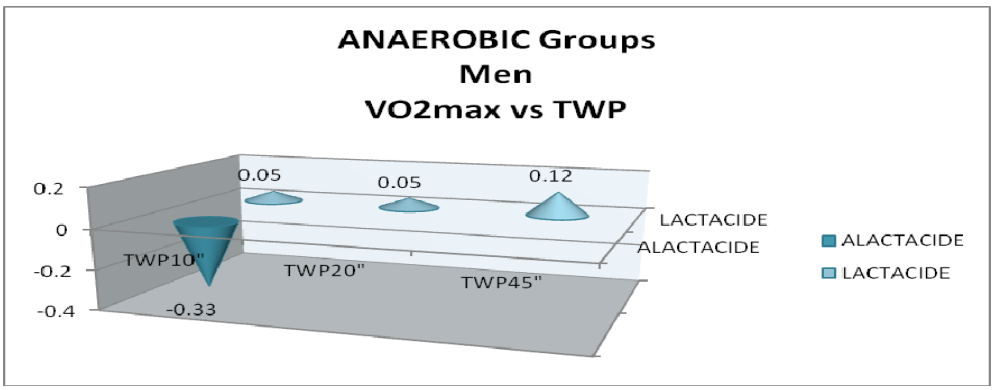

Figure 12. The correlation between VO_2max vs TWP at anaerobic male group

This tendency remained for the anaerobic alactic group also for the correlation between the VO_2max and the Peak Power, although the correlation coefficient didn`t touch the significant threshold (p>0.05) (Fig.13).

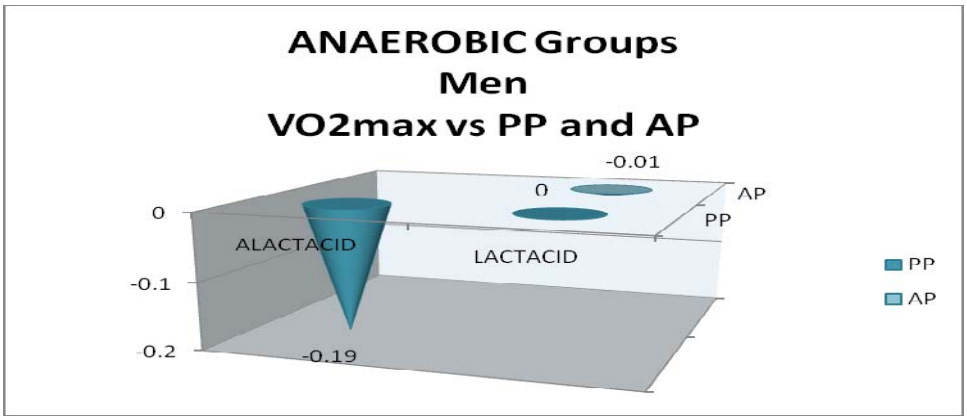

Figure 13. The correlation between VO_2max vs PP and AP at anaerobic male group

Discussions

From this study, it could be concluded that the effort adaptation is being done differently in women and men, probably due to the particular functionality of the muscle fibers in the two genders, being present before the training. The daily physical activities of women rely mainly on the slow oxidative muscle fibers (SO), whereas men use the fast-oxidative fibers (FOG) more. It was proven significant correlations between SO twitches and I type fibers, FOG and II A type fibers, FG and IIX type fibers (9, 20, 21). This theory is backed up by the superior percentage of the type I fibers compared to the type IIA found by different authors in untrained women, whereas, for untrained men, the percentage of the type IIA fibers outweighs that of the type I fibers (4, 14, 15).

The anaerobic training produces in both sexes the accessing of the functional reserves of the IIX fibers, but in the case of the women, it accesses the functional reserves of the type IIA fibers also, which are rarely used in the absence of training and contain both glycolitic and oxidative enzymes. Thus, the anaerobic training in women causes improvements for the oxidative metabolism, unlike the men, in which the anaerobic training doesn`t influence positive the oxidative system, because it relies predominantly on the high functional reserves of the type IIX fibers (exclusively anaerobic) and less on the reduced reserves of the IIA type fibers (mixed fibers, anaerobic and aerobic). In fact, increasing the alactic anaerobic performance in men appears by accessing the functional glycolitic reserves of IIX fibers and through the conversion of the IIA fibers into IIX fibers, with a consecutive loss of the oxidative capacity and, consequently, of the maximum oxygen uptake. Meanwhile, the functional glycolitic reserves of women, larger than those of men, since they comprise both the IIX and the type IIA fibers, delay the conversion of the fibers which also have an oxidative (IIA) into fibers with a solely glycolitic metabolism (IIX). We can thus explain why the very high intensity, short duration training which characterizes the physical training in the alactic anaerobic trials corroborated with decreasing the maximum oxygen consumption only in the male anaerobic alactic group, while the female anaerobic groups, both alactic and lactic, registered positive correlations with the maximum oxygen consumption.

Fiber conversion, although present in the male anaerobic alactic group, didn`t happen for the male anaerobic lactic group, fact expressed through the lack of negative correlations between the maximum oxygen consumption and the anaerobic effort parameters for this group. The possible explanation for this fact is the increasing needs of fatigue-resistant fibers (FOG) that the performance in this type of trials implies, which prevented the conversion of the type IIA (FOG) fibers into IIX (FG) fibers, with low fatigue resistance. The fact that, in these sports, the muscle power relies to a great degree on the FOG fibers, unlike the anaerobic alactic sports, in which the predominant fibers in the muscle power generation are the FG fibers, is highlighted also

by the TPP parameter, whose average is over 5 seconds on the anaerobic lactic trials and under 5 seconds in the alactic ones.

In a similar way, the endurance training implies high values of the oxygen consumption, which is done through adaptive modifications on a peripheral level developing the oxidative capacity of the muscle fibers. For men, accessing the high functional reserves of the type I fibers represents the primary muscle adaptation for the endurance effort, while for women, the endurance and anaerobic efforts rely initially on the functional reserves of the type IIA fibers, which can explain the emergence of the positive correlations between the maximum oxygen consumption and the anaerobic parameters in the female group with mixed energogenesis, but not in the male one.

The muscle fibber conversion in the great endurance training is possibly realized after accessing the functional oxidative reserves of the fibers to the maximum, both in men and women, idea sustained by the significantly negative correlations between the maximum oxygen consumption and the performance parameters of the maximal effort on the aerobic groups, both male and female, characterized by the highest values of the maximum oxygen consumption.

Concerning the fiber type between which the conversion appears in high level endurance training, there are, again, differences between women and men. In women, the conversion probably consists in the transformation of the IIA type fibers (fast, fatigue resistant fibbers) into slow type fibers (I), while in men, there is a conversion of the IIX type fibers (fast, low resistance to fatigue fibers) into IIA type fibers. For this reason, in the case of the female aerobic group, the negative correlation coefficients with the maximum oxygen uptake were higher when the anaerobic parameters specific for the late phases of the anaerobic effort (sustained by fast, fatigue resistant fibers) were taken into account. Conversely, in the male group, the parameters from the beginning of the maximal effort (sustained by fast, low-resistance to fatigue fibers) presented higher negative correlations with the maximum oxygen uptake compared with those characteristic to the last phases of the maximal effort.

Conclusions

The results of this study confirm that the effort adaptation is different in women compared to men. Training a particular energetic pathway can have negative or positive effects on the other one, based on the athlete`s gender and the training's level.

We believe that, although these conclusions need further studies in order to be considered valid, the training programs of high performance athletes should take into account these particular aspects.

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The rehabilitation treatment in carpal tunnel syndrome associated with diabetes mellitus (case report)

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Abstract. Carpal Tunnel Syndrome (CTS) is a common peripheral neuropathy. The anatomical configuration of the carpal tunnel is that of an inelastic channel. Any increase in its volume or alteration in shape will usually result in a significant increase in interstitial pressure. Systemic associated diseases (for example diabetes) can be considered cause CTS. The efficacy of different types of electrotherapy for painful peripheral neuropathy has been evaluated in many studies. We describe the rehabilitation treatment effect in the CTS with diabetes mellitus etiology.
Case report. A 52-years-old female person, with diabetes mellitus type II, non-insulin dependent, with symptoms of CTS, that do not yield to treatment with NSAIDs and analgesics. Electrodiagnostic evaluation confirmed diagnosis of carpal tunnel syndrome, radiography of the wrist and right hand and the carpal tunnel sonography do not revealed changes which would suggest a local cause of the carpal tunnel syndrome. Rehabilitation program (electrotherapy, massage, physical exercises, occupational therapy) is aimed to reducing pain and numbness, maintain the pain-free range of motion and muscle toning, increase the ability of the hand. *Conclusion*. Rehabilitation treatment has had a favorable impact on patient's symptoms, leading to pain and numbness disappearance, daily activities can be performed without difficulty and the Sensory Nerve Conduction Velocity (CV) increased with 36 %.
Key words: *peripheral neuropathy, diabetes mellitus, rehabilitation*.

Introduction

Carpal Tunnel Syndrome (CTS) is a common peripheral neuropathy affecting up to 4% of the general population, typically women in the late middle age (1). This disease causes are either local, lead to a decreasing diameter of carpal tunnel or general causes, which lead to changes of the median nerve. Systemic diseases associated with an increased incidence of developing carpal tunnel syndrome are hypothyroidism, rheumatoid arthritis and diabetes mellitus but systemic diseases represent only a small part of all causes (2). Diabetes mellitus lead to changes in the peripheral nerve, due to both metabolic disorders as well as damages of blood circulation which can cause ischemia of median nerve.

Generally accepted treatment includes general measures, non-steroidal anti-inflammatory drugs, steroids and surgical treatment. Patients with carpal tunnel syndrome should avoid repetitive wrist and hand motions that may exacerbate symptoms.Current recommendations are non-steroidal anti-inflammatory drugs as initial therapy, followed by more aggressive options if symptoms do not improve (3). The treatments can include: steroids either orally or injected locally, splinting, and surgical release of the transverse carpal ligament (4).

The benefit of steroid treatment is transient (5). Local corticosteroid injections are only used until other treatment options can be identified. For most, surgery is the only option that will provide permanent effect (6).

Rehabilitation treatment uses different methods of physical therapy for release the symptoms of CTS (pain, numbness) and improve the nerve conduction. In this paper it will be presented a case report, which confirms the favorable effect of the rehabilitation treatment at a patient which has been treated with non-steroidal anti-inflammatory drugs and analgesics, without results. The patient was diagnosed with type II diabetes which implies cautions at treatment with NSAIDs and corticosteroids.

Case report

The patient presented, is a woman under the age of 52 years old, living in urban areas. Hereditary pathological histories were insignificant. Personal pathological histories: type II diabetes mellitus, non-insulin-dependent five-year-old treated with

oral anti-diabetic agents (Siofor 1000 mg, 1tablet /day) and an essential hypertension was diagnosed seven years ago controlled with medication.

The history of disease. The patient has been presented with characteristic symptoms developing with carpal tunnel syndrome, pain and paresthesia at finger I-III of the right hand in the median nerve territory, sensation of muscle weakness.

The patient have had these symptoms for a long period of time, approximately six months, the symptoms have had increased in the last three months, without yielding to treatment with NSAIDs and analgesics.

She patient was diagnosed with diabetes mellitus five years ago and has presented in the course of the disease values of blood sugar over the normal, values between 130 -180 mg/%

Physical exam: positive Tinel□s sign, hypoesthesia in the territory of the median nerve innervations, without muscle weakness.

Laboratory investigations. Glycaemia had a value of 136 mg%. Electrodiagnostic evaluation confirmed diagnosis of carpal tunnel syndrome showing at the median nerve a decrease in the Sensory Nerve Conduction Velocity (CV), a decrease of the Sensory Nerve Action Potential (SNAP) amplitude (tab. I)

Table I. EMG measurements before treatment

Sensory nerves	Lat (ms)	Amp (µV)	CV (m/s)
Palm-Wrist	3.0	7.9	29.3
Dig.I -Wrist	2.8	14	38.1
Dig.II -Wrist	3.6	5.7	31.3
Dig.III -Wrist	3.9	13	35.3
Dig.IV -Wrist	3.7	13	41.4

Motor Nerve Conduction Velocity of median nerve has been within normal limits. X-ray examination: radiography of the wrist and right hand do not revealed bone or joint changes which would suggest a local cause of the carpal tunnel syndrome. (fig.1). Carpal tunnel sonography has shown an increase of the median nerve area of 15 mm^2 and flattening of the median nerve in the distal tunnel, without any other changes in structures of carpal tunnel (fig.2).

Figure 1.Wrist and hand X - ray, face

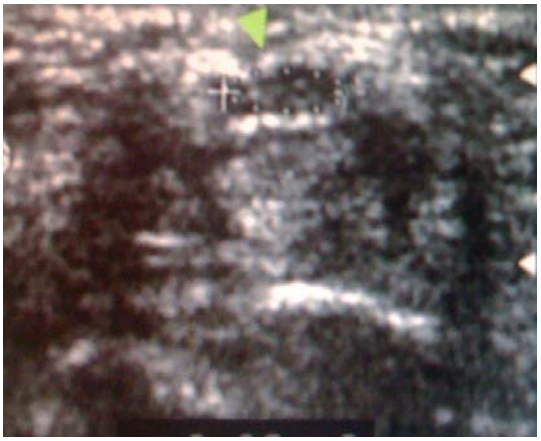

Figure 2. Carpal tunnel ultrasound

Positive diagnosis. The symptoms, physical exam and electrodiagnostic evaluation confirm diagnosis of carpal tunnel syndrome. *Differential diagnosis*. X-ray examination and carpal tunnel ultrasond excluded local causes (tendinitis, bone or joint changes, tumors) that may cause developing carpal tunnel syndrome and medical history and physical exam exclude other general causes. We can say that developing carpal tunnel syndrome is caused by diabetes.

Rehabilitation program

The rehabilitation treatment goals were: reducing pain and paresthesia, maintain the pain-free range of motion and muscle toning, increase the ability of the hand.

The treatment have been applied for 15 days and consisted in electrotherapy, massage and kinetotherapy.

Electrotherapy: TENS - the frequency 150Hz, 100ms pulse duration, for a period of application layer 15 minutes, currents of medium frequency - frequency 100-250 Hz, and 50 mA current intensity, time of application 15 minutes.

Massage of the hand and upper limb. Classic massage improves the blood circulation, stimulates skin receptors with analgesic effect. Deep longitudinal compression-relaxation methods have been used on the forearm flexors to regain optimum tone in those tissues. Massage has been followed by movement of wrist and fingers.
Kinetotherapy. For this patient we considered to following exercises to maintaining free range of motion for the wrist joint, muscular tone of hand and upper limb muscles, using strengthening exercises, isometric, eccentric, concentric and isotonic exercises, increase the ability of the hand and improve common daily activities (occupational therapy)
Mobility of wrist joint is increased using flexion, extension and circle motions.
Exercises for Carpal Tunnel Syndrome include exercises for wrist, hand, fingers and forearm.
Isometric and stretching exercises can strengthen the muscles in the wrists and hands, the fingers and wrist flexors muscles, the thumb muscles, improving blood flow to these areas.
Stretching forearms muscles reduces tension in the wrist. Isotonic exercises for flexor muscles of wrist and fingers increase the tonus and endurance. It is also training the force of finger-pinches.
Occupational therapy presents the ergonomic work-site, and ergonomic positioning of the hand and the body in daily activities.

Results

After the treatment, patient evaluation showed the disappearance of pain and numbness, the absence of any disorder of sensitivity, perform daily activities without difficulty.
Carpal tunnel sonography has not submitted changes after the treatment but electrodiagnostic evaluation showed growth of the Sensory Nerve Conduction Velocity (CV), with 36% as compared to the initial value, and the Sensory Nerve Action Potential (SNAP) (tab. II).

Table II. EMG measurements after treatment

Sensory nerves	Lat (ms)	Amp (μV)	CV (m/s)
Palm-Wrist	3	15	46
Dig.I-Wrist	2.5	14	45.5
Dig.II-Wrist	3.3	17	44.0
Dig.III-Wrist	3.3	13	46.2
Dig.IV-Wrist	3.4	14	40.0

Conclusions and discussion on the case

Since patient history, the physical exam and investigations tasks is not revealed the existence of local causes or other systemic diseases, except for diabetes to determine the carpal tunnel syndrome, we can say that the etiology of carpal tunnel syndrome is diabetes.
The effect of rehabilitation treatment under peripheral nervous system disorders, has been demonstrated by a number of different studies that have shown favorable effect of electrotherapy which has been shown to enhance microcirculation and endoneural blood flow (7), analgesic effect or improvement in nerve function as evaluated by electrophysiological parameters after moderate exercise training in patients with type II diabetes mellitus (8).
There are studies which present that therapeutic ultrasound may provide short-term pain relief in some patients (9). Others papers present that ultrasound therapy combined with massage and kinesiotherapy brings the long-term effects in patients with carpal tunnel syndrome (10).
A combination of muscle splint with lumbrical intensive stretches, as a method of conservative carpal tunnel syndrome treatment, was the most effective combination for improvements in functional gains in CTS (11).
The conclusions derived by the authors about electrotherapy effect are diverse so it is difficult to issue recommendations for the use of a single treatment (12).This paper presents a complex rehabilitation treatment which included electrotherapy, massage, kinesiotherapy, occupational therapy with favorable effect for patient.

Conclusions

1. Although developing carpal tunnel syndrome of diabetes mellitus etiology has a reduced frequency must consider this possibility and to appeal to the investigations: radiography and carpal tunnel sonography.
2. Rehabilitation treatment including physiotherapy, massage and physical exercises has had a favorable impact on patient's symptoms, leading to pain and paresthesia disappearance, an effect that has not been obtained using analgesics.
3. Rehabilitation treatment led to a significant improvement to electromyography changes, after the treatment, increase of the Sensory Nerve Conduction Velocity (CV) with 36%, even if carpal tunnel sonography has not been obtained changes.

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