BIO Web of Conferences **48**, 01008 (2022) https://doi.org/10.1051/bioconf/20224801008
2nd SPORT LIFE XXI

Interrelation between physical activity and hamstring flexibility among university students

Artem Moment[1*]
[1]Health Protection and Physical Culture Chair, Institute of Education and Social Studies, Pskov State University, Russia

Abstract. In recent time, the specialists in the field of physical education and health protection have no consensus on the need to include stretching exercises as an obligatory type of physical activity for apparently healthy young people. The problem is that most university students tend to have sedentary lifestyle. According to some reports, this can negatively affect the flexibility of the hamstrings and, as a result, lead to a decrease in physical performance. To maintain and develop flexibility, special stretching techniques are traditionally used, which caused the point about the necessity to include them in weekly physical activity. The opposite position is that flexibility is perfectly developed and maintained through the performance of healthier types of physical activity. In this case, the flexibility of the hamstrings should be correlated with the amount of physical activity. The aim of the research was to study the relationship between the amount of physical activity of students and the flexibility of the hamstrings. To achieve this aim, a correlation study was conducted. The results of the study showed that there is a noticeable significant correlation between the total value of physical activity of students and the flexibility of the hamstrings. This, in turn, is an additional reinforcement of the position that there is no strict need to include stretching as an obligatory component of the physical activity of university students to maintain and develop the flexibility of the hamstrings.

1 Introduction

A sedentary lifestyle is an urgent problem for the physical health and well-being of a modern person. This type of behavior can be characterized as the performance of actions or their absence in the awakening state in the sitting, reclining and lying positions with metabolic processes not exceeding 1.5 metabolic equivalents (MET) [1, 2]. University students, due to their lifestyle, represent the part of the population that is most likely to lead a sedentary lifestyle [3, 4].

The World Health Organization (WHO) has developed recommendations on the volume and content of physical activity and the prevention of sedentary lifestyles for all age groups. The content of motor activity for adults involves the implementation of aerobic physical activity and strengthening exercises [5].

*Corresponding author:ar.moment@yandex.ru

These types of physical activity simulate the formation of specific morphological and functional adaptations that improve the activity of the cardiovascular and nervous systems, strengthen the musculoskeletal system and, as a result, improve the quality of life among students, their effectiveness in learning and their physical health [6-8]. Along with this, many researchers [9-11] point out that one of the components of working efficiency and physical fitness is flexibility.

Flexibility refers to the intrinsic properties of body tissues that determine the maximum range of motion of joints without causing injury [10, 12]. The range of motion in a joint depends on two components: its own range of motion, limited by the type of joint, individual anatomical features of the structure of bones and their joints; ligaments, muscle length and compliance of the musculotendinous unit (MTU) [13], characterized by muscle tone, elasticity and rigidity. Flexibility measurements are used by researchers to assess the ability of the MTU to elongate [14].

It has been shown that stiffness of the hamstrings is one of the main factors that reduce performance in everyday life and sports activities [15]. For this reason, special attention is paid to the assessment of hamstring flexibility [16]. In particular, there is evidence of a relationship between low flexibility of the hamstrings, impaired posture and gait biomechanics [17]. Some studies show that a permanent sedentary lifestyle has a negative impact on flexibility, in particular on the flexibility of the hamstrings [18, 19].

Traditionally, special stretching techniques in various forms and protocols have been used to improve and maintain flexibility: static stretching, ballistic stretching, proprioceptive neuromuscular stretching [20], active isolated stretching [21], non-ballistic active stretching [22], etc. The American College of Sports Medicine recommends that adults, along with aerobic and strength exercises, pay attention to stretching exercises at least 2-3 times a week [23].

At the same time, the current WHO guidelines [5] on physical activity and a sedentary lifestyle do not provide a recommendation for stretching exercises. There is an evidence indicating that flexibility is excellently developed and maintained through other healthier types of physical activity, such as strengthening exercises [24]. In that respect, there is a contradiction regarding the consistency of opinions among experts on the need to include stretching exercises in the weekly physical activity of apparently healthy young people to maintain and develop flexibility of the hamstrings.

It has been hypothesized that if flexibility is developed and maintained through the performance of healthier physical activities rather than specific stretching techniques, then it will be positively correlated with the amount of physical activity.

The aim of the research is to study the relationship between the amount of physical activity of students and the flexibility of the hamstrings.

2 Materials and methods

To achieve this aim, on the basis of the Department of Physical Culture and Health Protection of the Institute of Education and Social Sciences of the Pskov State University, we conducted the study to find out the correlation between the amount of physical activity of students and the flexibility of the hamstrings, which was approved by the Ethics Committee of the Pskov State University. The method for assessing the magnitude of students' physical activity was self-report using the Short Version of the International Physical Activity Questionnaire (IPAQ-SF), and hamstring flexibility was assessed using the active knee extension test (AKET).

2.1 Organization of the research

Apparently healthy male students (N=22) of Pskov State University were invited to take part in the study (Fig. 1.). They were informed about the purpose and procedure of the study and signed an informed consent. The inclusion criteria were:

– absence of injuries of the lower extremities in the last 6 months, no acute and chronic diseases of the musculoskeletal system, no neurological conditions that can affect the flexibility of the hamstrings;

– lack of systematic (4-7 times a week) practice of stretching exercises;

– body mass index ≤ 29.9 kg/m^2.

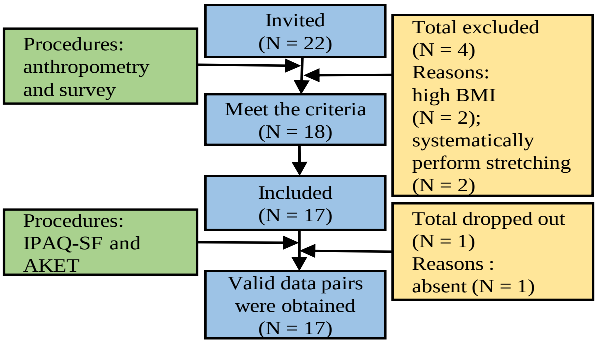

Fig. 1. Design of the research.

2.2 Measurement of anthropometric characteristics and interview

All subjects of the research underwent a standard procedure for measuring anthropometric characteristics such as body weight and length, followed by the calculation of the body mass index (BMI), which was defined as body weight in kilograms divided by the square of body length in meters (kg/m^2). After anthropometric measurements, the subjects were asked a series of questions in order to clarify their compliance with the inclusion criteria.

2.3 Assessment of the value of physical activity

Assessment of the value of physical activity was made by means of the automated self-report (IPAQ-SF). It has acceptable measurement characteristics, at least as sufficient as other self-reports [25]. This questionnaire includes 7 questions about the time spent in vigorous (VPA) and moderate (MPA) physical activity, walking and sitting during the last week. In accordance with this information, automatic calculation of energy costs (MET min/wk) was carried out for three components of physical activity and their total (Total) value, as well as the average value of the time spent on weekdays in a sitting position (SB, min). Automated IPAQ-SF report in Excel format was taken from the site (https://sites.google.com/site/theipaq/scoring-protocol).

In order to avoid overestimating one's own level of intense physical activity and underestimating moderate physical activity, which is shown in some IPAQ-SF validity studies [26, 27], completion of this self-report was carried out in collaboration with a consultant from the Department of Physical Education and Health Protection, to whom the subject could address for clarification.

2.4 Assessment of hamstring flexibility

Hamstring flexibility was assessed by AKET. This test provides a more isolated assessment of hamstring flexibility than the sit-and-reach and toe-touch tests [16]. Measurement of the extension angle of the left and right knee joint was carried out using a smartphone accelerometer. This method is an effective tool for measuring the range of motion in the knee joint during dynamic extensor movements [28].

2.4.1 Test protocol

For the purpose of warming up and kinesthetic training, the person tested walked along the perimeter of the sports hall with a total distance of 150 meters. Then he took the preparatory position to perform AKET. In the preparatory position, 3 consecutive knee extensions were performed with the maximum possible, but relatively comfortable amplitude. The extreme position of extension was held for 5 seconds. Then the lower leg returned to its preparatory position. An interval of 15 seconds was maintained between repetitions.

After performing the warm-up exercises and kinesthetic training, a smartphone with special software was fixed on the test person's lower leg, which recorded the data of the accelerometer indicators. The test protocol corresponded to the previously described parameters. Initially, the left limb was tested, and then the right limb. During the active knee extension, the instructor controlled the position of the torso, pelvis and hip of the test person in order to avoid changing the initial parameters of the posture (Fig. 2.).

Fig. 2. Performing AKET with an instructor.

2.4.2 Preparatory position

The person tested was in the initial position sitting on a flat stable horizontal surface (140 × 60 cm) at a height of 80 cm from the floor. The trunk was positioned strictly vertically while preserving the natural size of the physiological bends of the spine. The hip of the tested limb was positioned at an angle of 90° relative to the trunk and aligned parallel to the horizontal surface. To maintain the specified angular parameters, a fabric roller was used, installed under the distal part of the thigh and adjusted in height individually for each subject. The lower leg is relaxed and freely lowered down.

2.4.3 Smartphone attachment

The smartphone was attached on the lateral part of the lower leg of the person tested by means of a design developed by the author, which includes: two elastic straps, a plastic ruler, a silicone case. The silicone case was aligned relative to the vertical and horizontal axes of the plastic ruler and secured to it with a double-sided adhesive tape.

The design was fixed on the lower leg of the person tested with elastic straps holding the edges of the plastic ruler. The edges of the plastic ruler were oriented to the proximal (lateral condyle of the tibia) and distal (lateral ankle) anatomical landmarks of the shin bones (Fig. 3.).

Fig. 3. Smartphone attachment.

2.4.4 Smartphone specification

Model: Honor 20 lite MAR-LX1H (Manufacturer Huawei, China, 2019); Size: 152.9× 72.7 × 7.4 mm; Weight 159 grams; Processor: Hisilicon Kirin 710, 2.2 GHz; RAM: 4 GB; Operating System: Android version 10.

2.4.5 Software for recording accelerometer data

The accelerometer data was recorded using the Accelerometer Meter software version 1.32 (http://www.keuwl.com/Accelerometer).The developer company is Keuwlsoft (the UK, London). The value of the parameter "φ" - the absolute angle of twisting – was taken as the angle of the knee extension. Sampling rate is 50 Hz.

Since with the maximum extension of the knee, some dynamics of the lower leg oscillation is observed [29], the value of the active knee extension index was fixed for each limb as the average value of the extension angle for 5 seconds in the best of three attempts.

2.5 Statistical analysis

Visual (histograms and normal probability graphs) and analytical (Kolmogorov-Smirnov and Shapiro-Wilk test) methods were used to check the normality of the distribution. Due to the fact that some variables did not pass tests for the normality of the distribution, the analysis of the level of relationship between AKET and each category of IPAQ-SF was carried out using Spearman's rank correlation method. Statistical data processing and analysis was carried out in the STATICTICA 10 program (the developer company is StatSoft, the USA, Oklahoma, Tasla). Statistical significance was assumed at $p \leq 0.05$.

3 Results

This study involved 17 practically healthy students aged 21.3 ± 2.1 years. The general characteristics of the sample are presented in Table 1.

Table 1. General characteristics of the sample.

Variables	N	M	SD	Min	Max
Bodyweight, kg	17	78.7	14.8	46.0	100.0
Bodylength, cm	17	177.1	5.8	167.0	190.0
BMI, kg/m2	17	25.0	4.1	15.9	29.7
Walking, MET min/wk	17	2404.1	1451.4	462.0	4158.0
MPA, MET min/wk	17	447.1	390.6	0.0	1440.0
VPA, MET min/wk	17	1007.1	731.7	0.0	2400.0
Total, MET min/wk	17	3858.3	1765.9	937.5	7038.0
SB, min	17	585.9	112.8	360.0	720.0
AKET (l), □	17	18.1	8.6	6.1	32.5
AKET (r), □	17	17.6	9.1	2.5	30.4

Note: N - number of observations; M - average value; SD - standard deviation; Min - minimum value; Max - maximum value.

The group average values of the anthropometric characteristics of the sample were: body weight 78.7 ± 14.8 kg; body length 177.1 ± 5.8 cm; BMI 25.0 ± 4.1 kg/m^2. The group average values of physical activity variables were: walking 2404.1 ± 1451.4 MET min/wk; moderate physical activity 447.1 ± 390.6 MET min/wk; intense physical activity 1007.1 ± 731.7 METmin/wk. Physical inactivity on weekdays on average in the sample was 585.9 ± 112.8 min. The flexibility of the hamstrings according to AKET for the left and right extremities was 18.1 ± 8.6° and 17.6 ± 9.1°, respectively.

Table 2 shows the correlation between all categories of IPAQ-SF and AKET.

Table 2. Correlation of variables IPAQ-SF and AKET (N = 17).

Variables	Walking	MPA	VPA	Total	SB
AKET (l)	-0.33	-0.42	-0.33	-0.53*	0.06
AKET (r)	-0.35	-0.33	-0.34	-0.51*	-0.01

Note: * □ $p \leq 0.05$.

A statistically significant correlation was found between the flexibility of the hamstrings of the left (-0.53) and right (-0.51) limbs according to AKET and the total amount of physical activity according to IPAQ-SF. The correlation has a negative value, since the lower the value in AKET, the more flexible the hamstrings are considered. No significant correlation was found between specific API-SF categories and hamstring flexibility at the established significance level. The high duration of students being in a sitting position during the school week was not associated with the flexibility of the hamstrings.

4 Discussion

The aim of the research was to study the relationship between the amount of physical activity of students and the flexibility of the hamstrings. The results of the study allowed us to confirm the hypothesis of a positive relationship between the amount of physical activity of students and the flexibility of the hamstrings.

The results obtained are partly consistent with earlier studies [30], where a reliable positive relationship was shown between MET min/wk in all categories of IPAQ-SF (walking, intense and moderate physical activity) and hamstring flexibility in the sit-and-reach test in adults. In another study [31], a weak but statistically reliable relationship was established between the flexibility of the hamstrings of the right limb according to AKET and the average score on the Global Physical Activity Questionnaire (GPAQ) among university students.

Group average values of hamstring flexibility according to AKET (left limb: 18.1 ± 8.6°; right limb: 17.6 ± 9.1°) correspond exactly to the average normative value (17.8 ± 9.1) for males aged 18-24 years [16], in some cases there were no values of the knee extension angle >33.0, which could indicate hamstring stiffness. Thus, students who did not perform systematic stretching exercises and were in a sitting position for a long time on weekdays (585.9 = 112.8 min) had acceptable indicators of hamstring flexibility. However, students who devote more time to physical activity are likely to have more flexible hamstrings.

The main difference from the results obtained by other researchers is that no reliable correlation was found between the volume of a specific component of physical activity according to IPAQ-SF and the flexibility of the hamstrings. However, this does not at all refute the existence of this relationship. The obtained values of the correlation between the total amount of physical activity and the flexibility of the hamstrings are also higher than in early studies, which may be due to various reasons.

The small sample size did not allow the subjects to be divided into more homogeneous subgroups to compare the benefits of certain types of physical activity or their absence on the flexibility of the hamstrings in students. It should also be noted that the subjects practicing resistance training (N=3), when filling out IPAQ-SF, faced difficulties in interpreting the duration and intensity of their classes, which is caused by the presence of rest intervals between approaches and exercises. It was decided to include the main part of the training in the intensive physical activity section entirely, which could contribute to the overestimation of this category of IPAQ-SF in these subjects. The question of objective accounting of resistance training in IPAQ-SF remains open.

5 Conclusions

The total amount of physical activity of students is positively associated with the flexibility of the hamstrings. The results of the study have theoretical significance, as they allow physical education teachers at university, based on scientific data, to give sound recommendations to practically healthy students regarding the optimal content of their weekly physical activity, which do not imply strictly mandatory inclusion of stretching exercises to maintain and develop flexibility of the hamstrings.

References

1. M. Fanchamps, van den Berg – Emons, H., Stam, H., &Bussmann, J, Sedentary behavior: Different types of operationalization influence outcome measures. Gait & Posture, 54, 188-193. doi: 10.1016/j.gaitpost.2017.02.025, (2017)
2. M. Tremblay, S. Aubert, J. Barnes, T. Saunders, V. Carson, A. & Latimer-Cheung, et al., Sedentary Behavior Research Network (SBRN) – Terminology Consensus Project process and outcome, International Journal Of Behavioral Nutrition And Physical Activity, 14(1) (2017). doi: 10.1186/s12966-017-0525-8
3. A. Carballo-Fazanes, J. Rico-Díaz, R. Barcala-Furelos, E. Rey, Rodríguez-Fernández, J., Varela-Casal, C., &Abelairas-Gómez, C., Physical Activity Habits and Determinants, Sedentary Behaviour and Lifestyle in University Students, International Journal Of Environmental Research And PublicHealth, 17(9), 3272, (2020). doi: 10.3390/ijerph17093272
4. R. Vella-Zarb, F. Elgar, The 'Freshman 5': A Meta-Analysis of Weight Gain in the Freshman Year of College. Journal Of American College Health, 58(2), 161-166 (2009). doi: 10.1080/07448480903221392
5. F. Bull, Al-Ansari, S. Biddle, K. Borodulin, M. Buman, G. Cardon et al., World Health Organization 2020 guidelines on physical activity and sedentary behaviour. British Journal Of Sports Medicine, 54(24), 1451-1462 (2020). doi: 10.1136/bjsports-2020-102955
6. C. Herbert, F. Meixner, C. Wiebking, V. Gilg, Regular Physical Activity, Short-Term Exercise, Mental Health, and Well-Being Among University Students: The Results of an Online and a Laboratory Study. Frontiers In Psychology, 11 (2020). doi: 10.3389/fpsyg.2020.00509
7. L. Dyrbye, D. Satele, T. Shanafelt, Healthy Exercise Habits Are Associated With Lower Risk of Burnout and Higher Quality of Life Among U.S. Medical Students. Academic Medicine, 92(7), 1006-1011 (2017). doi: 10.1097/acm.0000000000001540
8. A. Makhov, I. Medvedev, The effect of regular physical activity on the functioning of the nervous system. DusunenAdam, 9, 794-798 (2018).
9. R. Meroni, C. Cerri, C. Lanzarini, G. Barindelli, G. Morte, V. Gessaga, Comparison of Active Stretching Technique and Static Stretching Technique on Hamstring Flexibility. Clinical Journal Of Sport Medicine, 20(1), 8-14 (2010). doi: 10.1097/jsm.0b013e3181c96722
10. R. Kell, G. Bell, A. Quinney, Musculoskeletal Fitness, Health Outcomes and Quality of Life. Sports Medicine, 31(12), 863-873 (2001). doi: 10.2165/00007256-200131120-00003
11. C. Araújo, Avaliação da flexibilidade: valoresnormativos do flexiteste dos 5 aos 91 anos de idade. Arquivos Brasileiros De Cardiologia, 90(4) (2008). doi: 10.1590/s0066-782x2008000400008
12. J. Nuzzo, The Case for Retiring Flexibility as a Major Component of Physical Fitness. Sports Medicine, 50(5), 853-870 (2019). doi: 10.1007/s40279-019-01248-w
13. R. Nelson, W. Bandy, An Update on Flexibility. Strength And Conditioning Journal, 27(1), 10-16 (2005). doi: 10.1519/00126548-200502000-00001
14. D. Hunter, J. Spriggs, Investigation into the relationship between the passive flexibility and active stiffness of the ankle plantar-flexor muscles. Clinical Biomechanics, 15(8), 600-606 (2000). doi: 10.1016/s0268-0033(00)00017-6

15. Y. Nishikawa, J. Aizawa, N. Kanemura, T. Takahashi,, N. Hosomi, H. Maruyama et al., Immediate effect of passive and active stretching on hamstrings flexibility: a single-blinded randomized control trial. Journal Of Physical Therapy Science, 27(10), 3167-3170 (2015). doi: 10.1589/jpts.27.3167
16. M. Yıldırım, F. TunaD. DemirbağKabayel, N. Süt, The Cut-off Values for the Diagnosis of Hamstring Shortness and Related Factors. Balkan Medical Journal, 35(5), 388-393 (2018). doi: 10.4274/balkanmedj.2017.1517
17. C. Whitehead, S. Hillman, A. Richardson, M. Hazlewood, J. Robb, The effect of simulated hamstring shortening on gait in normal subjects. Gait&Posture, 26(1), 90-96 (2007). doi: 10.1016/j.gaitpost.2006.07.011
18. T. Chaves, D. Balassiano, C. Araújo, Influência do hábito de exercícionainfância e adolescêncianaflexibilidade de adultossedentários. Revista Brasileira De Medicina Do Esporte, 22(4), 256-260 (2016). doi: 10.1590/1517-869220162204159118
19. M. Jabbar, A. Mustansar, S. Arif, T. Ayub, Prevalence of Hamstring Tightness Due to Prolonged Sitting Among Administrative Staff of Government College University, Faisal Hospital and Commissioner Ofce Faisalabad. Pakistan Journal Of Physical Therapy (PJPT), 28-32 (2021). doi: 10.52229/pjpt.v4i1.994
20. A. Hedrick, Dynamic Flexibility Training. Strength And Conditioning Journal, 22(5), 33 (2000). doi: 10.1519/00126548-200010000-00010
21. T. Kochno, Active Isolated Stretching (The Mattes Method). Journal of Body work and Movement Therapies, 6(4), 226–227 (2002). doi:10.1016/S1360-8592(01)90255-4.
22. W. Webright, B. Randolph, D. Perrin, D, Comparison of Nonballistic Active Knee Extension in Neural Slump Position and Static Stretch Techniques on Hamstring Flexibility. Journal Of Orthopaedic & Sports Physical Therapy, 26(1), 7-13 (1997). doi: 10.2519/jospt.1997.26.1.7
23. C. Garber, B. Blissmer, M. Deschenes, B. Franklin, M. Lamonte, I. Lee et al., Quantity and Quality of Exercise for Developing and Maintaining Cardiorespiratory, Musculoskeletal, and Neuromotor Fitness in Apparently Healthy Adults. Medicine & Science In Sports & Exercise, 43(7), 1334-1359 (2011). doi: 10.1249/mss.0b013e318213fefb
24. R. Simão, A. Lemos, B. Salles, T. Leite, E. Oliveira, M. Rhea, V. Reis, The Influence of Strength, Flexibility, and Simultaneous Training on Flexibility and Strength Gains. Journal Of Strength And Conditioning Research, 25(5), 1333-1338 (2011). doi: 10.1519/jsc.0b013e3181da85bf
25. C. Craig, A. Marshall, M. Sjöström, A. Bauman, M. Booth, B. Ainsworth et al., International Physical Activity Questionnaire: 12-Country Reliability and Validity. Medicine & Science In Sports & Exercise, 35(8), 1381-1395 (2003). doi: 10.1249/01.mss.0000078924.61453.fb
26. P. Lee, D. Macfarlane, T. Lam, S. Stewart, Validity of the international physical activity questionnaire short form (IPAQ-SF): A systematic review. International Journal Of Behavioral Nutrition And Physical Activity, 8(1) (2011). doi: 10.1186/1479-5868-8-115
27. K. Joseph, H. Dagfinrud, A. Christie, K. Hagen, A. Tveter, Criterion validity of The International Physical Activity Questionnaire-Short Form (IPAQ-SF) for use in clinical practice in patients with osteoarthritis. BMC Musculoskeletal Disorders, 22(1) (2021). doi: 10.1186/s12891-021-04069-z

28. M. Støve, T. Palsson, R. Hirata, Smartphone-based accelerometry is a valid tool for measuring dynamic changes in knee extension range of motion, The Knee, 25(1), 66-72 (2018). doi: 10.1016/j.knee.2017.11.001
29. B. Stillman, Physiological quadriceps lag: Its nature and clinical significance. Australian Journal Of Physiotherapy, 50(4), 237-241 (2004). doi: 10.1016/s0004-9514(14)60113-6
30. C. Silva-Batista, R. Urso, A. Lima Silva, R. Bertuzzi, Associations Between Fitness Tests and the International Physical Activity Questionnaire—Short Form in Healthy Men. Journal Of Strength And Conditioning Research, 27(12), 3481-3487 (2013). doi: 10.1519/jsc.0b013e31828f1efa
31. A. Gite, N. Mukkamala, L. Parmar, Relationship between Body Mass Index and Flexibility in Young Adults. Journal Of Pharmaceutical Research International, 119-126 (2021). doi: 10.9734/jpri/2021/v33i32a31723