



Relationship between Body Mass Index and Flexibility in Young Adults

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Authors' contributions

This work was carried out in collaboration among all authors. Authors AG, NM, LP were involved in conception of idea and study design. Author AG did the data collection. Authors AG and NM performed the statistical analysis. Authors AG and NM managed the literature searches. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/JPRI/2021/v33i32A31723

Editor(s):

(1) Dr. Asmaa Fathi Moustafa Hamouda, Jazan University, Saudi Arabia.

Reviewers:

(1) Jolanta Grażyna Zuzda, Białystok University of Tehnology, Poland.

(2) Motahareh Hasani, Iran University of Medical Sciences, Iran.

Complete Peer review History: <http://www.sdiarticle4.com/review-history/68875>

Original Research Article

Received 10 April 2021

Accepted 14 June 2021

Published 18 June 2021

ABSTRACT

BACKGROUND: Flexibility is important for general health and fitness, athletic performance, injury prevention and rehabilitation. Sedentary behavior of students leads to decreased physical fitness levels which affects flexibility. There is little evidence regarding relationship between BMI and flexibility.

Aim: To study the relationship between BMI and flexibility and BMI and physical activity in young adults.

Study Design: Observational study

Place and Duration Of Study: The study was carried out at College of Physiotherapy, Sumandeep Vidyapeeth, Vadodara from September 2019 to March 2020.

Methods: Males and females between 18 to 30 years were included in the study. BMI, Sit and Reach Test for low back and hamstring flexibility, Active Knee Extension Test (AKET) for hamstrings and Global Physical Activity Questionnaire (GPAQ) for physical activity levels were assessed.

Results: 570 participants with mean age of 20.23±2.07 years were included. Mean BMI was 21.83±4.81 kg/m². Number of females were 462 and males were 108. There was no significant correlation between BMI and flexibility of low back ($P=.247$) and hamstring (Rt) ($P=.668$) (Lt)

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($P=.354$). BMI and GPAQ showed a statistically significant association ($P=0.02$). There was a weak positive correlation which was statistically significant between GPAQ and SART ($P=0.000$) and a weak negative correlation which was statistically significant between GPAQ and Rt AKET ($P=0.004$).

Conclusion: There was no significant correlation found between BMI and flexibility. There was a statistically significant association between BMI and physical activity, a weak negative correlation between GPAQ and hamstring flexibility and weak positive correlation between GPAQ and SART.

Keywords: BMI; flexibility; SRT; AKET; GPAQ.

1. INTRODUCTION

Body Mass Index (BMI) is a simple index of weight-for-height that is commonly used to classify underweight, overweight and obesity in adults. "It is defined as the weight in kilograms divided by the square of the height in metres (kg/m^2)" [1]. BMI has increased its importance as a disease predictor, with the increasing prevalence of obesity in today's time. For Asia-Pacific Population WHO categorises BMI as: underweight ($18.5 \text{ kg}/\text{m}^2$), normal weight ($18.5\text{--}22.9 \text{ kg}/\text{m}^2$), overweight ($23\text{--}24.9 \text{ kg}/\text{m}^2$), and obese ($25 \text{ kg}/\text{m}^2$) [2].

Flexibility is defined as "the physiological range of motion of a given joint" which is important in performing simple or complex movements involved in daily activities [3]. It depends on a number of specific variables including distensibility of the joint capsule, adequate warm-up, and muscle viscosity. In addition, compliance of various other tissues such as ligaments and tendons affects the range of motion. As flexibility is joint specific, no single flexibility test can be used to assess total body flexibility, it varies according to the muscle involved.[4] Flexibility is one of the important physical parameters which is related to an athlete's performance and also to muscle injury. Poor flexibility specifically affecting the hamstrings muscle group, has been associated not only to muscle strains, but also to other conditions such as patellofemoral pain, low back pain. For flexibility assessment, the active knee extension test (AKET) and the straight leg raise test (SLR) are two of the most commonly used measures [5]. AKET has excellent inter-rater and intra-rater reliability for assessing hamstring tightness by using simple portable and inexpensive stabilizing apparatus in youngsters [6]. To assess low back and hamstring flexibility sit-and-reach test (SRT) has been commonly used. The SRT is proven to be better in measuring hamstring flexibility compared to low back flexibility [6].

The Global Physical Activity Questionnaire (GPAQ) was developed by the World Health Organization (WHO) for physical activity surveillance, including the assessment of physical activity trends over time. The GPAQ collects information about physical activity in three domains: work, travel, and recreation, as well as average time per day spent in sedentary behavior like sitting and reclining. GPAQ is scored in minutes per day (min/d) to provide standard behavioral units, rather than a questionnaire score that is unit-less which is very difficult to interpret and analyse. The first version of the GPAQ showed good test-retest reliability ($= 0.67\text{--}0.81$) [7].

A study done in UK revealed that university students spend 8 hours per day on sedentary activities such as studying, watching television, gaming, computer activities, sitting and talking, shopping and hanging out. Students' weight and overall health is greatly influenced by physical activity levels and sedentary behavior. It is also known and proven that decrease level of physical activity decreases physical fitness levels [8]. Flexibility is one of the components of physical fitness so in turn it can be affected. Most of the literature focuses on finding relationship of BMI between either cardiorespiratory endurance or physical fitness as a whole but only a few have studied the correlation between BMI and flexibility.

Thus the present study aims to find the relationship between BMI and Flexibility as well as BMI and physical activity in young adults.

2. MATERIALS AND METHODS

The study was registered with CTRI (CTRI/2019/09/028243) and was approved by Sumandeep Vidyapeeth Institutional Ethics committee. After getting approval, permission was sought from constituent institutes of Sumandeep Vidyapeeth. The study included both

males and females between 18 to 30 years of age. The subjects who had any history of pain, injury or surgery to the low back in the previous 6 months, musculoskeletal injury to the hip or knee that could hamper test performance, neurological condition affecting the lower extremities and subjects who were practicing flexibility exercise / yoga training daily were excluded from the study.

All the subjects were explained about the study and written Informed Consent Form was taken from those who were willing to participate. Participant information sheet was provided to the included subjects. All the subjects were screened for their physical activity levels using GPAQ on one-to-one basis.

A stadiometer measured the height of the subjects in centimeters. Subjects were asked to take their shoes off, keep their feet together, and place their arms at the side. Height was measured from the floor to the highest point on the head, with the subject looking ahead. Body weight was measured using an analogue weighing scale. Participants were made to stand with hands by their side. Shoes and excess clothing were made to remove and the weight was recorded.[9] BMI was calculated using the standardized formula " $BMI = \text{weight}/\text{height}^2$ (kg/m^2), where kg is person's weight in kilograms and m^2 is their height in meters squared".

To measure popliteal angle using AKET, a universal goniometer was used. Subjects were in supine position with the hip flexed to 90° and held by a popliteal bar and knee flexed. The testing was done on the right lower extremity and subsequently on the left lower extremity. The marking was done over the lateral condyle of femur. The fulcrum of the goniometer was centered over the lateral condyle of the femur. The stable arm was aligned with the long axis of femur using greater trochanter as a reference.

The movable arm was aligned with the lower leg using the lateral malleolus as a reference. The subject was then asked to extend the knee as far as possible until a mild stretch was felt. [5] Three repetitions were performed and an average of the three was taken as final reading of popliteal angle. The same procedure was repeated on the opposite side.

The flexibility test of SRT [10] was administered using a specially constructed box with a slide ruler attached to the top of the box. The height of the box was 33 cm. The subject was seated on the floor with both legs fully extended, shoulder width apart, and feet placed flat against the box. With one hand on top of the other and the knees fully extended, the participant slowly reached forward (without jerking) as far away as possible, sliding the hands across the top of the ruler, and held the final position for at least two seconds. The SRT score in centimeters was registered as the final position of the fingertips on or towards the ruler. The score was negative if the subject could not touch the front of the box where 21cm mark was present on the ruler and positive if it goes beyond that mark. The test was performed twice, and the average was calculated and recorded.

2.1 Statistical Analysis

The data was expressed as mean \pm standard deviation for nominal variables. Analytical Statistics – Pearson's correlation Coefficient was used to study the correlation between BMI, SRT, AKET and GPAQ. Chi Square Test was used to find the association between gender, BMI, SRT and GPAQ. The data was found to be normally distributed using Kolmogorov – Smirnov test of normality. Level of significance was fixed at $P < 0.05$. Confidence Interval was set at 95%.



Fig. 1. Active knee extension test



Fig. 2. Sit and reach test

3. RESULTS

A total of 570 subjects were included in the study. Age group included in the study were 18-30 years. Mean age and standard deviation of the subjects was 20.23 ± 2.07 years. Number of Females were 462 and Males were 108. Mean BMI and standard deviation of the participants was $21.83 \pm 4.81 \text{ kg/m}^2$.

4. DISCUSSION

In the present study, the average hamstring tightness using AKET for right and left side was $36.6 \pm 11.55^\circ$ & $31.4 \pm 12.48^\circ$ respectively, which shows that the hamstring flexibility of the population was low. Average value of SRT was 21.9 ± 7.6 cm which indicates poor flexibility of the hamstring and low back [6]. However, there was no statistically significant correlation between BMI and flexibility. Almost 90% of the participants were in the poor-fair category which was similar across all BMI categories. Similarly several studies did not show a statistically significant association between BMI and flexibility

[11,12,13,14]. In contrast, Jaraal S et al (2019) found an association between body mass index and flexibility [3].

One of the reasons for this could be inactivity of these adults. 61% of the young adults in the present study were found inactive according to GPAQ. We hypothesize that inactivity could lead to decreased flexibility. Most of the young adults now a days are not involved in physical activity leading to decrease in their physical fitness levels. Arora et al (2016) attributed decreased flexibility in the adolescents to poor posture. According to them, sedentary postures adopted for prolonged period and lack of adequate physical activity positions the hamstrings in a shortened position [11].

Minck et al (2000), studied association between physical fitness and body fatness as a measure of body composition in adolescents and young adults (13 to 27 years age group) and did not find a significant relationship between sit and reach test and body fatness [15]. In contrast, Pate et al. (1989) found a significant inverse relationship

Table 1. Mean and SD of various variables

Variables	Minimum	Maximum	Mean±SD
SART (in cm)	-5	39.5	21.9±7.6
AKET (Right) (in degrees)	8.5	65	36.6±11.55
AKET (Left) (in degrees)	10	56.3	31.4±12.48
SART in Male (in cm)	-2	45.5	19.47±8.09
SART in Female (in cm)	-5	39.5	19.55±7.71
AKET (Rt) in Male (in degrees)	18.3	61.3	34.3±10.49
AkET (Lt) in Male (in degrees)	16	56.3	30.8±10.15
AKET (Rt) in Female (in degrees)	8.7	65	37.2±11.73
AKET (Lt) in Female (in degrees)	10	48.7	31.6±12.97
GPAQ in Male	0	11760	1327.03±1159.91
GPAQ in Female	0	2520	553.09±1211.7

between fatness and the sit and reach test, but the correlations were low [16]. Deforsche et al (2002) showed that in tests that required flexibility, coordination, or speed of limb movement, excess fatness was not likely to hinder performance [13]. Zahra Asiri et al (2015) concluded that along with increase of BMI there is a decreasing tendency of fitness rate among which flexibility is one of the components [13]. A study done among children and adolescents aged 7 - 18 years found no significant association between SRT and BMI [14].

We did not get statistically significant difference between flexibility levels of both genders, but it was observed that males were more flexible [Table 1] in sit and reach test as well as active knee extension test for both the sides. Similarly, Jarral et al [3] also had male participants more flexible as compared to females because of high level of physical activity. In contrast Mistry et al [17] found females to be more flexible than males of the same age group, which they attributed to anatomical variation in the joints. But this author did not take BMI into consideration in their study, which was the objective of our study. They also found that flexibility is lower at higher and especially lower BMI which is similar to our study where we have found less flexibility in overweight individuals compared to normal participants [17].

In our study, from the total number of subjects taken, 350 were inactive participants, among which majority were females. One of the limitations in our study is gender inequality as there were only 108 male subjects, but still from the available data we obtained from GPAQ, the mean of males (1327.03 ± 1159.9) was more than double compared to females (553.09 ± 1211.7), after which it can be stated that males were more active than females. [Table 1] Azevedo, et al [18] showed that men presented higher activity levels than women in terms of moderate-intensity, vigorous-intensity and total leisure-time physical activity practice. Thapa et al found adolescent females were 5 times more likely to report low physical activity mostly because they were more involved in unpaid household work [19]. A WHO-led study (2019) says majority of adolescents

worldwide are not sufficiently physically active, putting their current and future health at risk. Their study finds that across all 146 countries studied girls were less active than boys. [20] Hamrik, et al reported that the level of physical activity decreased with age; men were more active than women and greater than 60% of adults in their study were rated 'sedentary' across all age categories [21].

Kumar et al (2018), showed that dependency on gadgets was high (45% among study subjects) among 21-24 years adults and most of them belonged to class I socioeconomic status [22]. But in our present study we have not studied this factor. In our population, college going young adults also lead a sedentary lifestyle as majority of the time they spend either studying during college hours or spending it with gadgets which is a common addiction in this age group [22]. Almost all of our participants were from health science university. In the medical field, studies are given more importance, most of the time is spent studying, and students have very less time for physical activity.

Similarly in other countries similar pattern of decreasing physical activity and increasing sedentary behavior is often seen during the secondary high school to university. Deliens et al (2015) in their study reported a review in Czech University students where 40-50% of college students were found to be physically inactive and only 9% fulfilled the criteria of 1000 steps everyday [9].

In the present study, we found a statistically significant association between BMI and physical activity levels. Hosseini, et al (2017) found that adolescents with vigorous level of physical activity were less prone to obesity than adolescents with mild level of physical activity, but the effect of moderate level of physical activity was not significant compared to mild physical activity on adolescent BMI. They also stated that by increasing physical activity levels in older children and adolescents there was reduction in BMI levels [23].

Table 2. Correlation coefficient for different variables

Variables	Pearson Correlation Coefficient (r)	P value
BMI and AKET(Rt)	.018	.668
BMI and AKET (Lt)	.039	.354
GPAQ and SART	.201	.000
GPAQ and AKET (Rt)	-.122	.004
GPAQ and AKET (Lt)	-.080	.055

Table 3. Association between BMI and SART

BMI	Sit and Reach Test (Low back and Hamstring Flexibility)					Total	Chi square = 11.59	P value = 0.23
	Poor	Fair	Good	Very good	Excellent			
Underweight		75 (57.25%)	46 (35.11%)	5 (3.8%)	5(3.8%)	0	131	
Normal		129 (54.43%)	92 (38.81%)	12 (5.06%)	4 (1.68%)	0	237	
Over weight		48 (65.7%)	19 (26.02%)	4 (5.47%)	1 (1.36%)	1(1.36%)	73	
Obese		60 (46.51%)	55 (42.63%)	11 (8.52%)	3 (2.32%)	0	129	
Total		312 (54.73%)	212 (37.19%)	32 (5.6%)	13 (2.28%)	1 (0.17%)	570	

Table 4. Association between BMI and GPAQ

BMI	Global Physical Activity Questionnaire		Total	Chi square = 9.48	P value = 0.02*
	Active	Inactive			
Underweight	43 (32.84%)	88(67.17%)	131(22.98%)		
Normal	84 (35.44%)	153(64.55%)	237 (41.57%)		
Over weight	29 (39.72%)	44(60.27%)	73 (12.8%)		
Obese	64 (49.61%)	65(50.38%)	129 (22.63%)		
Total	220 (38.59%)	350(61.4%)	570		

We did find a significant weak positive correlation between physical activity and low back and hamstring flexibility indicating that as physical activity increased, the values of SART increased i.e. physically active individuals were more flexible. Also a significant weak negative correlation was found between physical activity and hamstring flexibility indicating as physical activity increased AKET values decreased i.e. individuals became more flexible. The left hamstrings were more flexible than the right indicating asymmetry. This is in agreement with Radwan et.al's study which found asymmetrical tightness (left> right) in individuals with low back pain [24].

5. CONCLUSION

There was a weak negative correlation which was statistically significant between GPAQ and hamstring flexibility and weak positive correlation which was statistically significant between GPAQ and SART.

There was a statistically significant association between BMI and physical activity. There was no significant association between BMI and flexibility.

6. RECOMMENDATIONS

Further studies should be conducted involving all the age groups and people from all backgrounds.

7. LIMITATIONS

Limitations of our study was that most of the subjects in our study were females. Causal relationship between flexibility and physical activity cannot be established as this was a cross-sectional study.

CONSENT

The participants' written consent has been collected and preserved by the author(s).

ETHICAL APPROVAL

Institutional ethical approval was taken prior to the study.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Peer-review history:
The peer review history for this paper can be accessed here:
<http://www.sdiarticle4.com/review-history/68875>