Research article

A cross sectional study to analyse the correlation of body mass index with skinfold thickness and assessment of effect of training and its duration on agility, flexibility and their correlation among wrestlers

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ABSTRACT

Introduction and Aim: Physical fitness is a combination of several aspects rather than a single characteristic. Skill related components include agility, balance, coordination, these are regularly associated with motor skill performance. Composition of the body, its strength, endurance, flexibility, come under health-related components. Therefore, agility and flexibility are vital parameters for selection of wrestlers in various weight categories. The performance of the wrestlers is affected by reduced flexibility and agility. Ample literature is there in western countries in this area of research however very few studies have been performed on Indian wrestlers. Therefore, the aforesaid project was started for assessing the effects of training and its interval on agility and flexibility with age and sex matched healthy controls and among wrestlers and to find the correlation between flexibility and agility, on skinfold thickness and BMI.

Materials and Methods: Flexibility was assessed by sit and reach flexibility test and agility was tested with Illinois agility test for thirty-five wrestlers aged from eighteen to twenty-five years practicing regularly in district stadium was compared with age and sex matched controls.

Results: It was found that agility and flexibility were to be greater in wrestlers than controls and was significant statistically. Negative correlation was seen among BMI, flexibility, agility and Skin fold thickness, but not statistically significant.

Conclusion: It can be said that increased duration of training shows improvement in agility and flexibility thus decreasing the percentage of injury and refining the performance. Although there was not much difference with BMI and skinfold thickness with agility and flexibility.

Keywords: Wrestlers; agility; flexibility; BMI; skinfold thickness.

INTRODUCTION

Wrestling is a game which trials the strength, endurance, and talent of 2 players. It is like a physical chess match highlighting moves; counter stances, strength, acumen, stamina, & swiftness. Size is not a constituent in any wrestler's victory as in wrestling the opponents are of the same weight (1).

Physical health is still a multifaceted idea that has been characterized as a collection of traits that people possess or develop and which relate to their capacity to engage in physical exercise. Examining physical fitness offers a physiological state evaluation that may be used to the level of sports performance. It comprises health related, skill related, and physiological components. Agility, balance, coordination, which are mostly associated with motor skill performance are included in skill related components. strength of muscles, their endurance, elasticity, and physique composition come under health-related components. To demonstrate the importance of strength, power and muscle mass of Wrestlers, anthropometric measurements and fitness test scores have been previously related with play, and individual wrestler's achievement (2-4). Flexibility involves the capability of a person to change the body and its parts through as wide-range of movements as much as required yet devoid of any unnecessary strain to the articulations and muscle attachments. It further depends on certain factors, such as the joint capsule's distension, proper warming up, the muscle's viscosity, and the cooperation of many tissues, including ligaments and tendons, which control the range of motion. As flexibility is joint-specific, it is claimed that a single flexibility test cannot be utilized to assess entire body flexibility. Inactive lifestyle, age, excess amount of body fat, anxiety and stress, decrease the flexibility of the individual. Good flexibility of a joint can give a good work demo and reduce muscle damage and soreness and keep better health in general (5,6).

Agility physically enables an individual to swiftly change direction and body position in an accurate manner. It provides the capacity to move the body or body parts in space or on a surface while changing directions quickly and precisely. Since agility is a

combination of speed and coordination, it is an essential component in any situation requiring rapid-fire action, such as wrestling. (7,8). Therefore, in this aspect, it is necessary to easily, quickly, and exactly synchronize the vast muscles of the body that are engaged. In order to achieve this component, it's crucial to have innate talent and put in regular effort. In order to reduce the risk of injury, agility training has a beneficial impact on neuronal firing patterns, adaptation of the muscle spindle, Golgi-tendon apparatus, and joint receptors. Therefore, in order to have a more significant impact on a wrestler's performance, it is vital to understand whether there is a relationship between flexibility and agility. (9-13).

Composition of the body significantly affects the energy-related physical power and talent in various sports. BMI can be used to estimate the healthy weight. In a sportsman BMI is mainly contributed by increased muscle mass, then a rise in bodily fat. Perimeters of the limbs and trunk are occasionally used as relative indicators of muscularity. Body mass index is a direct calculation which defines relative weight for height, it is not sex specific and is significantly interrelated with total body fat content (4, 14-16).

Skinfold thickness is an indicator of subcutaneous adipose tissue. Its measurement requires precise calipers designed to apply the same tension throughout the range of motion. They provide an indication of subcutaneous fat. It is a simple and inexpensive technique for assessment of body composition. By the skinfold thickness one can find out body density and eventually body fat percentage using various formulas (Siri's equation; 4,16,17). Thus, analysis of body fat composition is frequently included in physical fitness assessment.

Flexibility, agility, and their relationships with body mass index and skinfold thickness are the ones that do not acquire the necessary significance, even though physical fitness is influenced by several criteria. The two most important factors that should receive greater attention, along with other fitness regimens, are BMI and skinfold thickness, to perform well in any sporting event. There is not much research in this area examining the relationship between flexibility and agility, as well as how they relate to SFT and body mass index. Western nations have conducted more studies in this area, but there is relatively little information accessible about wrestlers from south Asia. It is crucial to use a scientific method to analyze the game, choose wrestlers, train them, identify their weaknesses, and then improve game-specific talents. To determine the impact of training and its interval on agility and flexibility in wrestlers and healthy controls, as well as to determine whether there is a relationship between BMI and skinfold thickness and agility and flexibility, the present experiment was launched.

MATERIALS AND METHODS

When the institution's Ethics Committee on Human Subjects Research approved the study, it was carried out in the human physiology lab at JNMC, Belgaum. 35 wrestlers between the ages of 18 and 25 who regularly practiced at the district stadium were chosen. As controls, 35 students with matching sexes and ages were enrolled. Depending on the number of years of training, the wrestlers were divided into two batches. told permission was obtained from the individuals once they had been told about the nature of study.

Inclusion criteria

1. Strong wrestlers between the ages of 18 and 25 who have been competing regularly for more than two years.
2. For comparison, participants with similar ages and sexes who do not regularly engage in training or exercise were chosen.

Exclusion criteria

1. Players and the comparison group who have participants with neurological, muscular, pulmonary, endocrine, and cardiovascular diseases.
2. Comparative group participants who don't regularly practice meditation, physical activity, or sports.

Procedure (4, 9-19)

Height (cm): A commercial stadiometer was used to measure height. The participants were instructed to stand upright with their backs to the stadiometer's vertical backboard and their feet flat on the floorboard. It was observed that the participant's weight was evenly distributed over both feet. The heels of both feet were in contact with the underside of the vertical board.

Weight (kg): Participants were instructed to wear light clothing and stand barefoot while having their weight (kg) measured with a computerized device.

BMI: The equation was used to compute BMI.
BMI = body weight in Kg / (height in meters)^2

Skin fold thickness (mm): Skinfold calipers were used to quantify skin fold thickness (mm).

Measurements were obtained from the right side of the body, 1 cm from the thumb and finger vertical to the skin fold midway between the crest and base of the fold, at seven spots that were identified. The measurement was conducted while maintaining the squeeze. The two measures' means were taken into account.

- To isolate the triceps, a vertical fold was made on the back of the upper arm, midway between the acromion and olecranon process.
- One to two centimeters below the inferior angle of the scapula, the diagonal fold was taken in the subscapular region.
- At the level of the xiphoid process of the sternum, the midaxillary line's vertical fold was measured.
- The vertical crease in the abdomen was moved 2 cm to the umbilicus's right side.
- For the suprailiac space, the diagonal fold was taken at the iliac crest's angle in the anterior axillary line, which is directly above the iliac crest. In order to expand towards the pubic symphysis, the skinfold should slant 45 degrees downward and forward.
- The diagonal fold was obtained at the chest area, midway between the anterior axillary line and nipple.
- On the anterior midline of the thigh, midway between the inguinal crease and the proximal edge of the patella, a vertical fold was taken for the thighs. The subject was instructed to stand with his right leg out in front with his knee slightly bent and his foot flat on the ground, while his weight was distributed backward on his left leg.

Body density: The procedure for calculating the sum of the skinfold thicknesses at seven sites was used to calculate body density.

In the case of males, the equation is

1.112 ─ 0.00043499 (sum of seven skinfolds) + 0.00000055 (Sum of seven skinfolds)2 ─ 0.00028826 (age).

In the case of females, the equation is

1.097 ─ 0.00046971 (sum of seven skinfolds) + 0.00000056 (Sum of seven skinfolds)2 ─ 0.00012828 (age).

Percentage of body fat: In order to determine the percentage of body fat, the following equation (Siri's) was used:

4.950 ─ 4.500/Body density X 100

The Anand agencies' Sit and Reach flexibility testing tool was used to evaluate flexibility. The individuals were instructed to sit on the floor with their legs extended during the process. The participants were instructed to take off their shoes and maintain an upward toe position. Flat against the instrument's middle limbs, the soles were placed. By holding the knees down, which was aided by the examiner, it could be observed that they were locked into place and flat on the ground. The individual placed their hands on top of each other or kept them apart while they stretched their hands as far forward along the measuring line as they could. It was strictly enforced that no bouncing or diving movements were permitted during the push. It was observed that both hands continued to move forward jointly while remaining at the same level. The individuals were able to reach out and maintain that position for one to two seconds while the distance was measured after little practice. As the hand stretched the distance, the score was recorded in centimeters. The feet's level was used as the "0" mark. Agileness was recorded by Illinois agility procedure; apparatus required were marking plastic cones, stopwatch, measuring tape.

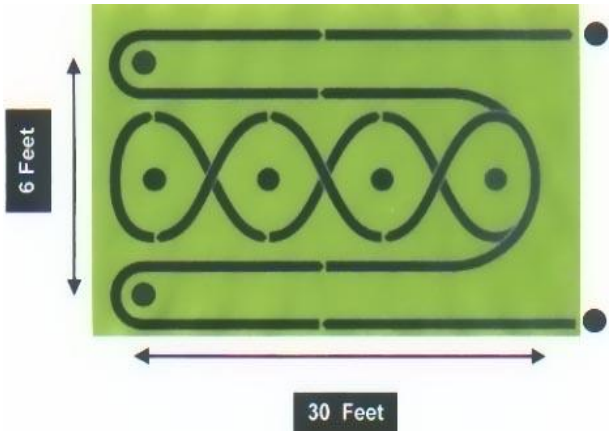

Fig. 1: Agility testing set up

The path was ten meters long, and there were five meters between the start and finish lines. The start, finish, and two turning points are marked with 4 plastic cones. (Fig. 1). Other 4 plastic cones were set in the middle at equal distance (3.3 meters) apart. Participants were instructed to bend forward with their hands by their shoulders and their heads towards the starting line. The runner must stand up as quickly as possible, sprint down the marked path in the direction specified, without tripping over the cones, to the finish line, when the stopwatch is stopped, and then the recording is halted. The standard scoring table is used to determine score.

The SPSS 16.0 software was used to conduct the statistical analysis. The standard deviation and mean of the quantifiable parameters were summarized. A 'P' value of less than 0.05 was considered significant when comparing the coefficient of variation between the two groups in a student's unpaired 't' test. Karl Pearson's approach was used to calculate correlation coefficients in order to evaluate the degree to which flexibility, agility, and SFT are related to BMI and body mass index.

RESULTS

The mean values of BMI, skinfold thickness was significantly higher in the control group. Mean values of the individual seven site circumferences were similar in both the groups except for the calf circumference which was more in the control group

and statistically significant (Table 1). Whereas mean BMI, skinfold thickness of the two wrestler groups did not show any significant difference. Individual values of seven site circumferences and mean skinfold thickness, body fat, and body density didn't give any statistical significant difference among both the groups (Table 2).

Table 1: Anthropometric parameters of wrestlers and control group

Parameters	Wrestlers	Controls	p-values
BMI (%)	20.8±2.07	21.9±3.30	0.05
Skinfold thickness (mm)	62.6±19.36	120.3±21.31	<0.001*
Body density	1.08±0.008	1.06±0.010	<0.001*
Body fat (%)	8.56±3.83	17.5±4.60	<0.001*

(*) p value < 0.05

Table 2: Anthropometric variables between the two groups of wrestlers

Parameters	Group 1(≥ 4yrs)	Group 2(< 4 yrs)	p -value
BMI (%)	21.2 ± 2.09	19.8 ± 1.3	0.065
Skinfold thickness (mm)	63.5 ± 13.88	61.6 ± 28.80	0.846
Body density	1.08 ± 0.009	1.06 ± 0.01	0.067
Body fat (%)	9.3 ± 4.12	13.8 ± 6.44	0.068

Group 1 = (≥4yrs), n = 24 Group 2 = (< 4 yrs.), n = 11
(*) p value < 0.05

Wrestlers were shown to have higher agility and flexibility scores than controls, as measured by the Illinois Agility Test and the Sit and Reach Test, with a P value less than 0.05; (Table 3). P value less than 0.05 revealed that Group 2 had a higher agility score than Group 1 according to the Illinois agility protocol. With a P value of <0.05 (Tables 3 and 4), group 1's flexibility score was higher than group 2's. Flexibility and agility were not shown to be correlated. However, there was no statistically significant negative (-ve) connection between agility and SFT, BMI, or flexibility.

Table 3: flexibility and agility scores between wrestlers and controls

Parameters	Wrestlers	Controls	p-value
Flexibility score (cm)	16.4±3.23	4.8±1.99	<0.001*
Agility score(sec)	16.1±1.64	19.6±1.59	<0.001*

(*) p value significance<0.05

Table 4: Flexibility and agility scores among the wrestler groups

Parameters	Group 1(≥ 4yrs)	Group 2(< 4 yrs)	p -value
Flexibility score (cm)	**18.1 ± 2.38**	**12.8 ± 0.87**	**<0.001***
Agility score(sec)	**16.1±1.64**	**19.6±1.59**	**<0.001***

(*) p value significance = < 0.05
Group 1= (≥ 4yrs), n = 24 Group 2 = (< 4 yrs), n = 11

DISCUSSION

In this study the total of SFT in all the 7 areas was greater in the control group than wrestlers signifying the more amount of subcutaneous fat among the controls. Body fat percentage was also higher among controls than wrestlers. Body density was greater in the wrestlers when compared with the controls and the values were statistically significant. These values signify that the wrestlers have slim bodies when paralleled to the typical, inactive, non-exercising controls which can be attributed to the long-term athletic training and the selection procedures.

There was no statistically significant difference between the two groups of wrestlers' mean body fat, skin fold thickness, and body density indices. According to one study, top wrestlers and amateurs had similar height, BMIs, and body fat percentages, but there was a noticeable difference in their sport-specific abilities (17).

Although there was no difference in anthropometric measurements between the groups, it is important to note that the body fat percentage was nearly the same in both batches with little variation, but there was a significant difference when compared to the amateur, inactive controls, indicating that wrestlers were slim. This supports the claim that wrestlers work to increase their lean body mass and decrease their fat mass. These findings support those of prior research, which show that prolonged wrestling training causes physiological changes (2,16,18, 20-22). The body fat percentages of various wrestlers were determined by past studies to be as follows: Turkish wrestlers (9.7%), Canadian team (17.2%), collegiate wrestlers (11.3%), Iranian wrestlers (10.6%), and U.S. team

(8.3%). The values in this study were (9.3% and 7.0%) for group 1 and group 2 respectively. Signifying ideal fat percent justified better performance.

Statistically significant lower flexibility score and better agility score was found in controls than wrestlers suggest that the wrestlers are extremely flexible and agile and have varied range of movements. This demonstrates how training improved the wrestlers' agility. The inactive lifestyle and excess body fat of the controls may be the cause of their lower flexibility scores. With a 'P' value of 0.05, Group 1 of the two groups of wrestlers was more adaptable. This can be a result of their stretching exercises during training. The results of the earlier studies indicate that flexibility is somewhat undervalued in wrestling, and it must not be deserted by any means in preparation because of its contribution in performing attack maneuvers in difficult positions (25-27). Extra devotion should be given to increase flexibility in the Group 2. Agileness by Illinois test revealed a greater agility score in Group 1 compared to Group 2. Better agileness by agility training programs have implications in executing the techniques to bring the opponent down to the mat. Wrestling requires fast turning during the game for which enhanced agility is very crucial. (7,23,24). Despite training, there was no increase in agility in research conducted by Singh *et al.,* (23). Another investigation confirmed that enhanced motor unit recruitment and firing patterns were to blame for the progress. Due to improved synchronization between the central nervous system signal and proprioceptive reaction, neuronal adaptation typically takes place when athletes respond (23). Flexibility impacts performance in a wrestling bout in a way that it terminates the opponent's hard movements, permits the avoidance of body contact, and it allows movement performance with better amplitude and adequate behavior on landing. Great flexibility aids in dodging various leg bouts and reduces injuries. Thus, flexibility training facilitates the win on the mat. Flexibility is very much interrelated to the athletes, jumping ability and also limb strength and hence flexibility is determined as an important aspect in most research studies that describes physical condition (23,24).

Some of the previous studies have revealed that wrestlers are not that flexible than non-wrestlers, and other strength athletes as gymnasts, but they had greater rotation and abduction/adduction, plus they have higher neck and wrist flexibility than nonathletic controls. There was also discriminating variance on comparing between successful and less successful wrestlers (25-27).

There was no correlation between flexibility and agility results in this study, it might be so as flexibility is one-way activity whereas agility is a multidirectional performance. And also no correlation of agility and flexibility with skin fold thickness, body mass index was seen.

Limitations and future scope

With these findings the present study proposes that future studies be undertaken: To compare physical fitness with the sport's specific skills between the two types of wrestling. And include extra parameters like EMG, whole body reaction time. And other, fitness and psychological factors which might affect the performance of wrestlers needs to be correlated. As yoga and meditation are known to improve flexibility, concentration, and quickness it is advisable to incorporate yoga and meditation as a part of their training.

CONCLUSION

As per the data analyzed and discussed here, it can be concluded that years of training have positive encouraging results on Physical fitness and the performance of the wrestlers. More overweight the person is, there will be reduced presentation in activities requiring body movement. Therefore the wrestler should avoid being overweight and maintain their physique. Wrestlers exhibit the required sport specific pattern of total body fitness, high degree agility, and flexibility. Performance abilities were not different between the two wrestler groups and were better than the normal values for the similarly aged inexperienced and untrained individuals. There was no association between agility and flexibility; and also, among agility/flexibility with skinfold thickness and body mass index. Additional work should be conducted on agility and flexibility with skin fold thickness, body mass to fill the gap in this area.

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CONFLICT OF INTEREST

The authors declare no conflicts of interest.

REFERENCES

1. Physical fitness- Wikipedia, the free encyclopedia, accessed from URL: http://en.wikipedia.org/wiki/physical_fitness
2. Horswill, C.A., Park, S.H., Roemmich, J.N. Changes in protein nutritional status of adolescent Wrestlers. Med Sci Sport Exer. 1990; 22:599-604.
3. Horswill, C.A. Applied physiology of amateur wrestling. Sports Med. 1992; 14(2):114-143.
4. Wilmore, J.H., Brown, C.H., Davis, J.A. Body physique and composition of male and female distance runners. Ann N Y Acad Sci 1977; 301:764-776.
5. Thakur, D., Motimath, B. Flexibility and agility among children and adolescent Athletes: An observational Study. Int J Physiother Res. 2014;2(4):653-656.

6. Dopsaj, M. Extent of flexibility among athletes in different sports games – Soccer, volleyball, basketball, and handball. Sci J Facta Univ. 1994;1(1):51-60.
7. Homoud, M.N. Relationships between Illinois agility test and reaction time in male athletes. Swedish J Sci Res.2015;2(3):28-33.
8. Shivalingaiah, J., Vernekar, S.S., Naik, A.S., Gowdar, S.S. Effect of training on agility, flexibility, its correlation, and its correlation with skin fold thickness and body mass index among runners. Natl J Physiol Pharm Pharmacol 2016; 6.
9. Johnson, B., Johnson, B.L., Nelson, J.K. Practical Measurements for Evaluation in Physical Education. 3rd ed. New Delhi: Surjeet Publications. 1988.
10. Balady, J.G., Gibbons, R.J., Bricker, J.T. ACSM'S Guidelines for Exercise Testing and Prescription. 6th ed. Philadelphia, PA: Lippincott, Williams, and Wilkins; 2000.
11. Laurel, T.M., Carrie, B.R., Sue, L.H., Peter J.A. Exercise management, concepts, and professional practice. 1st Ed. United states: Human Kinetics; 2003.
12. McArdle, W. D., Katch, F. I., Katch, V. L. Essentials of exercise physiology. 7th Ed. Pennsylvania: Lea and Febiger Publications; 1994.
13. Johnson, B.L., Nelson, J.K. Practical measurements for evaluation in physical education. 3rd Ed. New Delhi: Surjeet publications; 1988.
14. Bird, S.R. Exercise physiology for health professionals. 1st Ed. London: Chapman and Hall; 1995.
15. Body mass index – Wikipedia, the free encyclopedia. Available from URL: htp://en.wikipedia.org/wiki/Body_mass_index
16. Sinning, W. E. Anthropometric estimation of body density and total body fat from skinfold measurements. Med Sci Sports 1978;(10):243-249.
17. Pallares, J.G., Lopez, J. M, Muriel, G. X., MıkelIzquierdo, A.D. Physical Fitness Factors to Predict Male Olympic Wrestling. Performance. Eur J Appl Physiol, 2011;111:1747-1758.
18. Jackson, A. S., Pollock, M.L., Ward, A. Generalized equations for predicting body density of women. Medicine and Science in Sports and Exercise. 1980; 12:175-182.
19. Siri, W.E. Body composition from fluid spaces and density: analysis of methods. Nutrition. 1961;9:480-491.
20. Roemmich, J. N., Sinning, W. S. Weight loss and wrestling training: Effects on nutrition growth, maturation, body composition and strength. J Appl Physiol. 1997; 82:1751-1759.
21. Schmidt, W. D., Piencikowski, C.L., Vandervestre. Effects of competitive wrestling season on body composition, strength, and power in national collegiate athletic association division III college wrestlers. J Strength Cond Res. 2005; 19:505-508.
22. De Garay, A.L., Levine, L., Carter, L. E. L. Genetic and anthropological studies of Olympics athletes. New York: Academic Press,1974.
23. Singh, A., Boyat, A.V., Sandhu, J.S. Effect of a 6-week plyometric training program on agility, vertical jump height and peak torque ratio of Indian Taekwondo players. Sport Exer Med Open J. 2015;1(2):42-46.
24. Young, WB., McDowell, MH., Scarlett, BJ. Specificity of sprint and agility training methods. J Strength Cond Res.2001;15(7):315-319.
25. Mehdi, A., Alireza, R., Mohammad Ali, A. Comparison of physiological and physical fitness of junior young students in freestyle and Greco-roman Wrestling. Annals of Biological Research. 2012; 3(7):3223-3233.
26. Song, T.M., Garvie, G.T. Anthropometric, flexibility, strength, and physiological measures of Canadian wrestlers and comparison of Canadian and Japanese Olympic wrestlers. Can J Appl Sport Sci, 1980;5:1-8.
27. Mirzaei, B., Curby, D.G., Rahmani-Nia, F., Moghadasi, M. Physiological profile of elite Iranian junior freestyle wrestlers. J Strength Cond Res. 2009; 23(8): 2339.