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Association of Body Composition and Physiological Variables across High-Impact and Low-Impact Sports Persons of Punjabi University, Patiala

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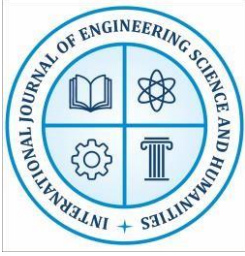
Abstract

The current research aimed to identify the relationship between the chosen body composition and physiological parameters between high and low impact sports at the Punjabi University, Patiala. The number of sports persons (high and low impact) (n= 60) with an age group of 18 years to 25 years was determined. Variables in the physiological category were vital capacity and blood pressure, whilst variables in the body composition category were Body Mass Index (BMI) and body fat percentage. The data analysis was conducted using descriptive statistics. The results showed that high-impact sports persons exhibited the best vital capacity and reduction in body fat percentage in relation to low-impact sports persons. The paper points to the role of the character of sports activity in determining the physiological efficiency and body composition.

Keywords: High-impact sports, Low-impact sports, Vital capacity, Blood pressure, Body composition

Introduction

Sports and physical activities are very crucial in the physical, physiological, and psychological growth of young people. Sports activities improve cardiovascular and respiratory fitness, muscle strength, physique and health, especially in students in the developmental age category of 18-25 years (Wilmore & Costill, 2004). Over the past few years, much focus has been on the learning of the effects of various categories of sports on the physiological and body composition parameters. Broadly, sports activities may be classified under high-impact and low-impact sports depending on the intensity of movement and the magnitude of mechanical stress on the body. Sports like athletics, football, basketball, and hockey are high-impact sports that require running, jumping and quick changes of direction, putting undue pressure on the respiratory and cardiovascular system. On the other hand, low-impact sports, such as table tennis, badminton (recreational), yoga, etc., include controlled movements with comparatively low physical load (McArdle, Katch, and Katch, 2015).



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Other physiological variables, such as vital capacity and blood pressure, are significant pointers of respiratory and cardiovascular efficiency. Vital capacity shows lung working capacity and lung endurance, which is imperative to maintain high-level physical activity, and blood pressure shows the cardiovascular health and circulatory efficiency (Guyton & Hall, 2011). It has also been proven that regular engagement in intensive physical activity increases the capacity of the lungs and keeps the blood pressure healthy (Astrand et al., 2003). On the same note, body composition factors, such as Body Mass Index (BMI) and body fat percentage, are also determinant factors of athletic performance and health. The lower body fat percentage and the ideal body mass index (BMI) relate to speed, agility and endurance, and excess fat accumulation could adversely influence performance and even health risks (Heyward & Wagner, 2004). The intense sports exercises have been shown to induce fat burning and fat build-up by increasing energy usage and metabolic adjustments (Powers and Howley, 2018). Although it has been established that sports participation is advantageous, there has been little research done that compares the physiological and body composition features between high and low impact sports individuals, especially among the students of a university. As a result, the current research will investigate and compare vital capacity, blood pressure, BMI, and body fat percentage of high-impact and low-impact athletes of Patiala city, thus leading to an improved perspective of the relevance of sport type in determining physical fitness and health.

Objectives of the Study

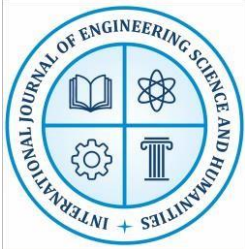
1. To compare vital capacity and blood pressure between high-impact and low-impact sports persons.
2. To compare body composition variables (BMI and body fat percentage) between high-impact and low-impact sports persons.
3. To examine the overall association of the type of sport with physiological and body composition variables.

Methodology

The current research was carried out in order to analyse the relationship between the physiological and body composition measures in high and low impact athletes. The method was developed in reference to the study objectives, which were to make comparisons between vital capacity, blood pressure, Body Mass Index (BMI), and body fat percentage of the two groups of sports persons.

Variables of the Study

The physiological variables chosen in the study were vital capacity, which was measured in litres, and the blood pressure, which included systolic and diastolic pressure, which were measured in millimetres of mercury (mmHg). These variables were taken to determine the efficiency of the respiratory and cardiovascular systems of the sports persons. The variables of body composition were Body Mass Index (BMI) and body fat percentage, which were chosen in order to assess the body weight status and fat distribution among athletes.



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Sample and Selection

The study was based on 60 sports persons as the sample of the study, who were chosen using purposive sampling. These were divided into 30 high-impact sports persons and 30 low-impact sports persons. The sample population was chosen in the city of Patiala, and their age was between 18 and 25 years. Male and female sporting personalities were not left out in an attempt to make the whole representation complete. The study was limited to the sports of high-impact and low-impact only, and only active athletes were taken into consideration, in line with the objectives.

Tools and Measurement

Vital capacity was assessed with the help of a spirometer, which gave a correct evaluation of lung capacity. A sphygmomanometer was used to check blood pressure after the usual resting protocols. The Body Mass Index was determined through the spirometer, which gave a normal formula of BMI by considering height and weight. The percentage of body fat was measured through the skinfold method or bio-electrical impedance method, which makes the body composition analysis reliable.

Delimitations

The study was limited to Patiala city sporting people. Only high-impact and low-impact sporting persons were considered in the investigation because the age was narrowed down to 18-25 years. The purpose of these constraints has been to make sure that it is consistent and relevant to the purposes of the study.

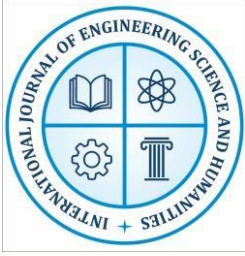
Objective 1

To compare vital capacity and blood pressure between high-impact and low-impact sports persons

Table 1: Comparison of Physiological Variables between High-Impact and Low-Impact Sports Persons

Group	Vital Capacity (Litres) Mean \pm SD	Systolic Blood Pressure (mmHg) Mean \pm SD	Diastolic Blood Pressure (mmHg) Mean \pm SD
High-Impact Sports Persons	4.42 \pm 0.36	118.07 \pm 5.95	75.52 \pm 5.12
Low-Impact Sports Persons	3.85 \pm 0.37	121.87 \pm 5.45	81.39 \pm 4.73

The initial hypothesis of the given research was to compare the selected physiological parameters, i. e., vital capacity and blood pressure, among high and low impact sports individuals. These are the key factors that reflect the respiratory and cardiovascular fitness and are directly related to the sports performance and the health condition of students. Students who play a game in the university will have varying physiological requirements with respect to the nature and intensity of sport, and



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this can lead to a potential variation in how the respiratory and cardiovascular systems can be adapted.

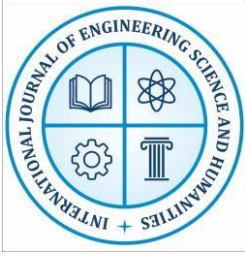
Vital Capacity in Relation to Student Games

Vital capacity is the largest volume of air that can be expelled forcefully after deep breathing. It is a major lung efficiency and stamina indicator, particularly in sports that demand a lot of exercising. Table 1 indicates that high-impact sport personalities had a greater mean vital capacity (4.42 ± 0.36 litres) than the low-impact sport personalities (3.85 ± 0.37 litres). This disparity can be attributed to the character of high-impact student games like football, basketball, athletics, hockey and kabaddi. These are games that require the player to run continuously, sprint a lot, jump and change the direction of movement very fast, which puts the respiratory system under more strain. To cope with these requests, the lungs change by enlarging their functional volume, and the respiratory muscles also get more powerful and efficient. Consequently, students who engage in high-impact games grow to have a deeper vital capacity over time.

Low-impact sports like table tennis, badminton (only at a recreational level), yoga and some indoor games are not based on long-term aerobic work but on skills, precision and coordination. Though these activities make a person fitter, they might not give enough stress to the respiratory system that will make an individual improve the lung capacity in a significant manner. This is the reason why the vital capacity of low-impact sports persons is relatively low, and high-impact sports persons have high vital capacity, enabling the student athletes to be active and endure longer periods of exercise, reduce fatigue and maintain performance during matches and training. Hence, the results indicate that high-intensity physical exercises are important in enhancing respiratory efficiency in students.

Systolic Blood Pressure and Student Athletic Activity

The systolic blood pressure indicates the force applied to the arterial walls at the time of contraction of the heart. It is a significant measure of cardiovascular performance. Table 1 indicates that high-impact sports persons recorded a low mean systolic blood pressure (118.07 ± 5.95 mmHg) in comparison with low-impact sports persons (121.87 ± 5.45 mmHg). Reduced systolic blood pressure in high-impact sports people would indicate improved cardiovascular conditioning. Regular high-impact sporting activities cause physiological adjustments, which include increased stroke volume and heart efficiency. Due to this, the heart is more efficient in pumping blood, and it does not need a lot of pressure to contract. Student athletes benefit positively through this adaptation because it decreases cardiovascular workload and increases endurance. Though physically exerted, low-impact sporting individuals can have a reduced effect on cardiovascular stimulation as they can be less intense and have less time on sustained movement. This could be the reason why systolic blood pressure values of this group were relatively high. In the case of students, particularly those with academic stress and abnormal lifestyle, frequent participation in high-impact sports will be useful in blood pressure control and in cardiovascular wellness.



Diastolic Blood Pressure and Cardiovascular Adaptation

The pressure that exists in the arteries during the rest between the heartbeats is called the diastolic blood pressure. It was presented in Table 1 that the mean diastolic blood pressure of high-impact sports persons was lower (75.52 ± 5.12 mmHg) than the mean diastolic blood pressure of low-impact sports persons (81.39 ± 4.73 mmHg). A decrease in diastolic blood pressure would mean that the heart relaxes more easily and the blood vessels are more elastic. The vascular flexibility and autonomic control would be enhanced during the training of high-impact sports, which will lead to lower blood pressure at rest. This is particularly favourable to the student athletes as it translates to an effective recovery and reduced cardiovascular load during rest. Low-impact sports persons might have high diastolic blood pressure due to the decreased cardiovascular load and inadequate exposure to extended aerobic exercise. Despite the fact that there are a number of benefits of low-impact sports, these may not be the most suitable activity that can help in inducing good blood pressure by stimulating the heart system.

Interpretation in the Context of Student Games

Comparison of vital capacity and blood pressure in high and low-impact sporting individuals shows that there are evident physiological benefits that are attached to high-impact sports. Students who play high-impact games exhibit a higher respiratory efficiency and cardiovascular regulation than those who play low-impact sports. These results highlight the significance of high-intensity physical exercises in sports programmes among students. Although low-impact sports are still significant in terms of training the skills and preventing injuries, combined training that involves the involvement of aerobic and conditioning exercises is necessary for the purpose of overall physiological development. The figures in Table 1 clearly show that high-impact sports persons have higher vital capacity and lower blood pressure than the low-impact sports persons. These findings indicate that high-impact games among students are important in increasing respiratory and cardiovascular fitness. Thus, the encouragement of engaging in sports with high intensity can help to enhance health, performance, and well-being in university students.

Objective 2

To compare body composition variables (Body Mass Index and Body Fat Percentage) between high-impact and low-impact sports persons

Table 2: Comparison of Body Composition Variables between High-Impact and Low-Impact Sports Persons

Group		Body Mass Index (BMI) Mean \pm SD	Body Fat Percentage (%) Mean \pm SD
High-Impact Persons	Sports	22.21 ± 1.89	14.06 ± 3.47



Group		Body Mass Index (BMI) Mean ± SD	Body Fat Percentage (%) Mean ± SD
Low-Impact Persons	Sports	23.49 ± 1.97	18.57 ± 3.21

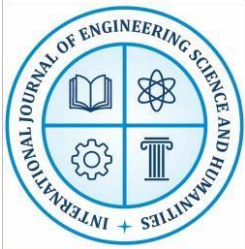
The second aim of the current research was to compare some of the body composition parameters, that is, Body Mass Index (BMI) and body fat percentage, of high and low impact sports persons. The body composition is an important aspect that determines physical fitness, athletes and overall health, especially in the case of student athletes. Various kinds of sporting activities require different levels of physical exertion, so they can lead to different adoptions of body weight variation and fat distribution.

Relationship between Body Mass Index and Student Games.

Body Mass Index is a very popular measurement to determine body weight depending on height and offers a rough estimate of the body weight status of an individual. The mean BMI of the high-impact sports persons was lower than that of the low-impact (22.21 ± 1.89 vs 23.49 ± 1.97), as indicated in Table 2. Even though the two groups are in the normal range of BMI, the lower BMI of the high-impact sports persons is a sign of good management of their weight and a healthy body image. This disparity is explainable by the fact that high-impact games among students like football, basketball, athletics, and hockey, and kabaddi have such characteristics. Constant running, sprinting, jumping, and high degrees of physical activity are included in these games, which increase the number of calories burned. Such activities, conducted regularly, can ensure that the students are in the best shape in terms of body weight and do not accumulate a lot of fat. Conversely, some sports like table tennis, badminton at recreational levels, yoga, as well as other skill games, require power to coordinate, be precise and skilled in technical performance, and do not involve a lot of physical effort. Although these sports are positive towards flexibility and mental focus, they might not produce a caloric burn to have any notable effect on body weight. Because of this, students who participate in low-impact sports might have a slightly higher BMI.

Fat Percentage of the Body and Sports.

A more accurate way to measure body composition is fat percentage because it is directly proportional to fat mass in the body. The results contained in Table 2 indicate that there is a significant disparity between the two groups. The mean body fat percentage of high-impact sports persons (14.06 ± 3.47) was significantly lower than that of low impact-sports persons (18.57 ± 3.21). Sports that are high impact require constant activity of large muscle groups, the use of both aerobic and anaerobic sources of energy. This training improves fat metabolism, elevates resting metabolic rate and ensures good hormonal changes that decline fat storage. High-impact games thus make student athletes develop leaner bodies with lower fat levels. Conversely, low-impact sports persons had greater body fat percentages, and this is possible because of the lower intensity



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of training and total energy used. Even though low-impact sports are associated with basic fitness and the prevention of injuries, they do not present a substantial stimulus to change the fat mass significantly. This is especially applicable to the students who might have long hours of inactivity in the academic work, not including sports involvement.

Impact of Body Composition on Student Athletic Performance

Student athletes must have a favourable body composition that can enable them to perform well in competitive sports. Small body fat percentage and ideal BMI lead to increased speed, agility, endurance and overall efficiency when at the games. The high-impact sports people have an advantage of having a higher power to weight ratio, which increases performance on the running, jumping and fast movement tasks. In the case of the students who are involved in low-impact sports, a slightly increased level of body fat might not directly impair the skill-based performance but might influence the overall fitness and long term health conditions. The use of supplementary conditioning and aerobic exercises may enable these students to attain a better body composition, as the results of Objective 2 are clear that high-impact sports participation is linked to excellent body composition among student athletes. The negative effects of intensive athletic activity on body composition are reflected in the lower body weight indexes and much lower content of body fats in high-impact sports persons. These findings underscore the need to have coordinated and balanced training programmes to enhance the best physical growth and health of students.

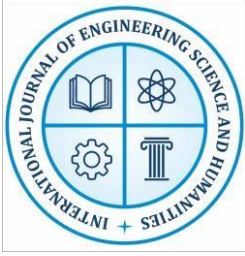
Objective 3

To examine the overall association of type of sport with physiological and body composition variables

Table 3: Association of Type of Sport with Physiological and Body Composition Variables

Variables	High-Impact Sports Persons (Mean \pm SD)	Low-Impact Sports Persons (Mean \pm SD)
Vital Capacity (Litres)	4.42 \pm 0.36	3.85 \pm 0.37
Systolic Blood Pressure (mmHg)	118.07 \pm 5.95	121.87 \pm 5.45
Diastolic Blood Pressure (mmHg)	75.52 \pm 5.12	81.39 \pm 4.73
Body Mass Index (BMI)	22.21 \pm 1.89	23.49 \pm 1.97
Body Fat Percentage (%)	14.06 \pm 3.47	18.57 \pm 3.21

The third aim of the current research was developed in an attempt to investigate the general correlation of the type of sport and the chosen physiological and body composition variables of sports persons. Sports activities were divided into games of high and low impact because these games have a great difference in terms of intensity, movement patterns, and physical requirements. Correlation between sport type and physical variables has a special significance when it comes to



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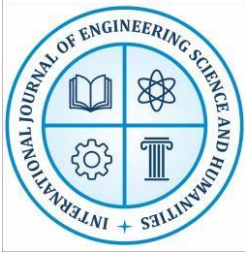
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student athletes because the factors can be used to determine the way that participation in various games affects health, fitness, and performance. Table 3 data shows a prominent correlation between the kind of sport and physiological variables. The mean vital capacity (4.42 ± 0.36 litres) of high-impact sports persons was higher than the mean vital capacity (3.85 ± 0.37 litres). This shows high respiratory efficacy among the students who participated in the high-intensity games. Vital capacity is an indicator of lung volume and endurance, which is needed to be able to maintain significant physical activity. Student games like football, basketball, athletics, hockey and kabaddi are high-impact games, which involve continuous running, sprinting, and jumping, thus causing a higher oxygen demand. When such demands are frequent, the breathing performance and the strength of the respiratory muscles will be enhanced.

High-impact sports persons also had low systolic and diastolic blood pressure values compared to low-impact sports persons, in addition to respiratory benefits. The average systolic blood pressure of high-impact sports persons was 118.07 mmHg, and low-impact sports persons were recorded to have a higher mean of 121.87 mmHg. The same case was also observed in diastolic blood pressure, where the high-impact sports persons (75.52 mmHg) had lower diastolic blood pressure compared to the low-impact sports persons (81.39 mmHg). These results indicate the improved adaptations in cardiovascular function in students who are engaged in high-impact sports. Constant physical activity increases the efficiency of the heart, increases the blood flow, and lowers the resting blood pressure, thus supporting the cardiovascular system. It is also seen in Table 3 that the relationship between the type of sport and body composition variables is present. The mean BMI of high-impact sports persons (22.21 plus 1.89) was lower than that of low-impact sports persons (23.49 plus 1.97). Though the two groups have a normal BMI range, the low BMI of the high-impact sports persons indicates that they have better weight management and a higher percentage of lean body mass. Sports that are high-impact are associated with high energy consumption, and this helps the students to be at their best body weight.

The difference in terms of body fat was more pronounced. The mean body fat percentage of high-impact sports persons (14.06 ± 3.47) was significantly less than that of the low-impact sports persons (18.57 ± 3.21). This shows that high-impact sports are more effective in lessening fat and enhancement of the general body build. Regular vigorous exercise improves the metabolism of fat and elevates resting metabolism. Thus, the findings show that there is a great relationship between the type of sport and the fitness of students in terms of sports games. Students who play high-impact games have a higher respiratory efficiency, cardiovascular regulation, and healthier body structure. These modifications are attributed to better athletic ability, decreased fatigue and potentially decreased health disorders related to lifestyle.

The low-impact sports are also significant in developing the students in the level of coordination, flexibility, performance of skills and prevention of injuries. The results, however, indicate that the low-impact sports may not be effective in eliciting the optimal physiological and body-



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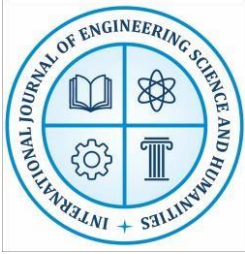
composition changes on their own. Consequently, the outcomes prove that there is a great correlation between the nature of sport and physiological and body composition parameters in the training programme of students involved in low-impact games. Athletic performance or high-impact sports activity among college students is linked to excellent respiratory efficiency, cardiovascular fitness, and positive body mass. Such results underline the significance of organised athletic activity and equal training courses in ensuring good physical fitness and health of student athletes.

Results and Discussion

The findings of the present research indicate the apparent distinction between high-impact and low-impact sports individuals in the mentioned variables of physiological and body composition. The high-impact sports persons had a higher vital capacity, implying they were more efficient at respiration. This improvement in the quality of the lungs can be attributed to the fact that the high-impact sports are dynamic and intense, and it entails running, jumping and long-term physical activity. Such exercises put the respiratory system under greater strain, and as such, the capacity of the respiratory lungs and the strength of the muscles to the lungs were found to be relatively low because they were compared to those of high-impact sport persons. A decrease in diastolic and systolic blood pressure is a pointer to enhanced cardiovascular performance and autonomic regulation of the heart. The active practise of high-impact sports has the beneficial effect of improving the pumping power of the heart, the elasticity of vessels, and the overall functioning of the circulatory system, which results in the development of more normal blood pressure indicators. Sports persons with low-impact sports may not receive as high a degree of cardiovascular adaptation due to the fact that their training is not very vigorous; on the other hand, body fat percentage was significantly below that of high-impact sports persons. The observation demonstrates the effectiveness of vigorous physical activities in fat burning and maintenance of lean body mass. Sporting activities that are intensive involve a high consumption of energy and utilise the large-scale muscles, resulting in fat burning. Nevertheless, low-impact sports individuals portrayed a rather large BMI and body fat percentage that would possibly be attributable to the existence of lower metabolic requirements and the reduction in total caloric cost. In general, the results are not new as the previous study has emphasised the positive impact of intense and vigorous physical activities on physiological fitness and body composition. The findings of the study have made it very clear that the character and the extent of sports activities are very important determinants that define respiratory, cardiovascular, and body composition characteristics of young sports individuals.

Conclusion

The research paper under discussion finds that high impact sport events lead to superior physiological functioning and superior body structure in comparison to low impact sport events. The high-impact sports persons would have a higher vital capacity, reduced blood pressure,



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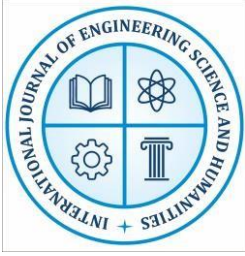
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reduced amount of fat within the body, which were reflective in better respiratory efficiency, cardiovascular adaptation and overall body fitness. These findings suggest that low-impact sports prove to be desirable when it comes to injury removal, development of skills, and coordination; however, they may not suffice in isolation to instigate optimal changes in physiological and body composition. Therefore, physical exercises of high intensity or vigorous nature ought to be incorporated in the training programmes to enhance fitness, performance and the general health of the sports persons in the long run.

References

- Astrand, P. O., Rodahl, K., Dahl, H. A., & Strømme, S. B. (2003). *Textbook of work physiology: Physiological bases of exercise* (4th ed.). Human Kinetics.
- Bouchard, C., Shephard, R. J., & Stephens, T. (1994). *Physical activity, fitness, and health: International proceedings and consensus statement*. Human Kinetics.
- Brooks, G. A., Fahey, T. D., & Baldwin, K. M. (2005). *Exercise physiology: Human bioenergetics and its applications* (4th ed.). McGraw-Hill.
- Guyton, A. C., & Hall, J. E. (2011). *Textbook of medical physiology* (12th ed.). Elsevier.
- Heyward, V. H. (2010). *Advanced fitness assessment and exercise prescription* (6th ed.). Human Kinetics.
- Heyward, V. H., & Wagner, D. R. (2004). *Applied body composition assessment*. Human Kinetics.
- Kenney, W. L., Wilmore, J. H., & Costill, D. L. (2015). *Physiology of sport and exercise* (6th ed.). Human Kinetics.
- McArdle, W. D., Katch, F. I., & Katch, V. L. (2015). *Exercise physiology: Nutrition, energy, and human performance* (8th ed.). Lippincott Williams & Wilkins.
- Powers, S. K., & Howley, E. T. (2018). *Exercise physiology: Theory and application to fitness and performance* (10th ed.). McGraw-Hill Education.
- Wilmore, J. H., & Costill, D. L. (2004). *Physiology of sport and exercise* (3rd ed.). Human Kinetics.
- Wilmore, J. H., Costill, D. L., & Kenney, W. L. (2008). *Physiology of sport and exercise* (4th ed.). Human Kinetics.
- American College of Sports Medicine. (2018). *ACSM's guidelines for exercise testing and prescription* (10th ed.). Wolters Kluwer.
- Malina, R. M., Bouchard, C., & Bar-Or, O. (2004). *Growth, maturation, and physical activity* (2nd ed.). Human Kinetics.
- Shephard, R. J. (1998). *Aging, physical activity, and health*. Human Kinetics.
- Baechle, T. R., & Earle, R. W. (2008). *Essentials of strength training and conditioning* (3rd ed.). Human Kinetics.
- Fox, E. L., Bowers, R. W., & Foss, M. L. (1993). *The physiological basis for exercise and sport* (5th ed.). Brown & Benchmark.



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An international peer reviewed, refereed, open access journal

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- Thompson, W. R. (2017). *Worldwide survey of fitness trends*. ACSM's Health & Fitness Journal, 21(6), 10–19.
- Reilly, T., Bangsbo, J., & Franks, A. (2000). *Anthropometric and physiological predispositions for elite soccer*. Journal of Sports Sciences, 18(9), 669–683.
- Paffenbarger, R. S., Hyde, R. T., Wing, A. L., & Hsieh, C. C. (1986). *Physical activity, all-cause mortality, and longevity of college alumni*. New England Journal of Medicine, 314(10), 605–613.
- Blair, S. N., Kohl, H. W., Gordon, N. F., & Paffenbarger, R. S. (1992). *How much physical activity is good for health?* Annual Review of Public Health, 13, 99–126.
- Janssen, I., & LeBlanc, A. G. (2010). *Systematic review of the health benefits of physical activity and fitness in school-aged children and youth*. International Journal of Behavioral Nutrition and Physical Activity, 7(40), 1–16.
- Caspersen, C. J., Powell, K. E., & Christenson, G. M. (1985). *Physical activity, exercise, and physical fitness: Definitions and distinctions*. Public Health Reports, 100(2), 126–131.
- Tomkinson, G. R., & Olds, T. S. (2007). *Secular changes in pediatric aerobic fitness*. Sports Medicine, 37(4–5), 405–424.
- Singh, H., & Singh, S. (2015). *Physical fitness and health status of university athletes*. International Journal of Physical Education, Sports and Health, 2(1), 15–18.
- Verma, J. P. (2012). *Sports research with analytical solutions*. Springer.