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The correlation between the body mass index, speed, and agility among athletes: a literature review

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Background: Athletes are prepared to adapt their body composition to the their sports. Biomotor components such as agility and speed are certainly one of important components to support the performance of an athlete. It is necessary to know more about the suitability of body composition needed for each sport that can improve performance in athletes. This study aimed to determine the relationship between BMI, speed, and agility among athletes.

Methods: This study used a literature review design to discuss the relationship between BMI, speed, and agility among athletes based on secondary data from published literature on Google Scholar and PubMed. The inclusion criteria used include: journals describing correlation between the body mass index, speed, and agility among athletes, journals published between 2015-2023. The exclusion criteria used include: excluding other articles if there are duplicates, excluding abstracts, theses, and dissertations.

Results: Based on the results of a review of five studies that discussed body mass index on speed and agility in athletes, it was found that four journals stated that there were significant relationships between BMI, agility, and speed, but there was one journal which found an insignificant relationship between BMI and agility for male athletes but it was significant for female athletes.

Conclusion: Agility and speed in athletes have a relationship with each BMI category. Athletes who were in the underweight BMI category would have better agility and speed compared to athletes who were in the overweight.

Keywords: agility, athletes, body mass index, speed, sport

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Background

The body's ability to carry out physical activity is very important to support the efficiency and productivity of each individual. This applies to every sector related to human life, including the sports sector. Each sport has certain anthropometric and biomotor component provisions that must be developed by athletes. The biomotor component is the ability that is the basis for carrying out physical activity.[1] Meanwhile, the anthropometric component is a measurement used to measure a person's body proportions and composition.

One anthropometric component that is an important indicator for an athlete is body mass index (BMI), which is a benchmark used to assess body proportions by comparing body weight and height (m^2). The World Health Organization developed an international classification for BMI, namely underweight (< 18.5 kg/m2), normal (18.5 ≤ BMI < 25 kg/m2), overweight (25 ≤ BMI < 30 kg/m2) and obesity (≥ 30 kg/m2). This measure is usually used in medical research and sports medicine.[2] Body composition influences an athlete's performance. Each sport has certain criteria that athletes in that sport must meet. A person who exercises will experience skeletal muscle hypertrophy, depending on how they train and their level of training. Therefore, an athlete may have a high BMI without excess body fat.[3] In some sports that focus on body size and weight such as wrestling, athletes with a higher BMI tend to be overweight because most wrestlers will try to increase muscle mass to win the competition. Meanwhile, sports that require the ability to move more quickly and agilely, such as rhythmic gymnastics, where athletes or ski jumping, where athletes usually have a BMI of around 16.6 kg/m2, will make athletes regulate their body weight to remain in the underweight category.[4,5]

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Agility or agility is one of the biomotor components that is quite important to train in athletes. Agility is a form of muscle contraction to perform dexterous movements or in other words, a person's ability to change the direction of movement of all body parts quickly and still maintain balance. Several factors that can influence agility are balance, strength and speed.[6] Speed is the ability of an individual to make movements in a short period. The speed component is the body's reaction time to something and the body's endurance in moving in a short time.[7]

One factor that influences speed and agility is BMI. Different BMI categories will certainly have different impacts. However, there are not many studies that discuss and compare this matter. Most studies only discuss specifics such as agility which is affected by overweight conditions but do not compare it with other BMI categories.

Therefore, this literature review was created to see the involvement of each BMI category (underweight, normal, overweight, obese) on speed and agility in athletes. Based on the introduction above, the author is interested in making a literature review with the title body mass index related to athlete's speed and agility.

Methods

The research method used is a literature review study. In compiling, the author used secondary data that has been published. A literature search was carried out online via Google Scholar and PubMed using the keywords “agility”, “speed”, “body mass index”, “underweight athletes”, and “overweight athletes”. The inclusion criteria used include: literature published in the last 10 years, the research sample is athletes, variables from the research include speed and agility. Meanwhile, the exclusion criteria used include: abstracts and thesis. The authors determined inclusion and exclusion criteria independently. The author reviews and reads all the literature in full to select literature that meets the inclusion and exclusion criteria. Based on the inclusion and exclusion criteria of 27 journals, the authors then eliminated them to obtain five articles that were displayed in the results section. Data was extracted by summarizing in a table containing data about the author, method and sample, measuring instruments, and results.

Results

The results of the journal search found 5 journals in the last 10 years which will be extracted into a table based on the required data. Based on the results of a review of 5 studies that discussed body mass index on speed and agility in athletes, it was found that 5 journals stated that there was a significant relationship between BMI and agility and speed, but there was 1 journal which found an insignificant relationship between BMI and agility for athletes but results of a significant relationship between BMI and agility for female athletes. The details can be seen in table 1.

Based on Dominado (2021)[14] showed that relationship between agility and body mass index. The study was conducted on 54 athletes (23 athletes in the underweight category, 27 athletes in the normal category, 2 athletes in the overweight category, and 2 athletes in the obese category). Inclusion criteria that used was athletes from Pampanga Province who competed in the Central Luzon Regional Athletic Association (CLRAA) in the 2019 – 2020 school year. There is a significant relationship between speed and body mass index (*p*-value 0.000) and also significant relationship between agility and body mass index and speed (*p*-value 0.000).

Based on Thakur (2016)[15] showed that relationship between body mass index and agility. The study was conducted on 45 male kabaddi athletes. Inclusion criteria that used was members of various teams participating in the inter-university Kabaddi tournament (2015-16) held at BHUVaransi (U.P) who are aged 20 – 25 years and are in the Obesity BMI category. BMI and Speed are strongly correlated in a positive direction (r=0.552). There is a significant relationship between body mass index and speed ($p<0.05$). BMI and Agility are strongly correlated in a positive direction (r=0.543).

Cinthuja *et al.,* (2015)[16] research, 183 badminton athletes (110 men and 73 women). Inclusion criteria that used was badminton athletes who consistently play badminton for more than 3 months in 11 schools (6 boys' schools and 5 girls' schools) in Kandy district who participate in the provincial badminton tournament are in the age category 9 - 15 years which has been approved by the parent/guardian. Exclusion criteria that used was badminton athletes who have a history of sports that cause asthma, have other medical problems such as heart or lung disease, have musculoskeletal disorders, and have experienced an injury 3 months before the study. BMI and speed in female athletes are weakly correlated in a positive direction (r=0.026). There is a significant relationship between body mass index and speed in female athletes (*p*=0.016). BMI and speed in male athletes are weakly correlated in a positive direction (0.031). There is a significant relationship between body mass index and speed in male athletes (*p*=0.007). BMI and agility in male athletes are weakly correlated in a positive direction (r=0.155). There is a significant relationship between body mass index and agility in male athletes (*p*=0.001).

Based on Wahono *et al.,* (2023)[8] data analysis was normality test using *the Sample Kolmogorov -Smirnov Test* and correlation test using bivariate analysis, namely Correlation Coefficient (*Pearson's*). The sample that used was 36 athletes (18 men and 18 women) in East Java handball. Inclusion criteria was East Java handball athletes in the age range 18 – 23 years. BMI and agility in male athletes are moderately correlated in a positive direction (r = 0.345). An insignificant relationship was found between BMI and agility in male athletes (*p* = 0.162). BMI and agility in female athletes are strongly

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correlated in a positive direction (r = 0.546). There is a significant relationship between BMI and agility in female athletes (p = 0.019).

Table 1. Results of searched articles regarding the body mass index (BMI), speed, and agility among athletes

Authors	Methods and Sample	Measurement Instruments	Results
Dominado (2021)	Method: Descriptive Correlational Design with Purposive Sampling. Sample (n): 54 athletes (23 athletes in the underweight category, 27 athletes in the normal category, 2 athletes in the overweight category, and 2 athletes in the obese category). Sample inclusion criteria: athletes from Pampanga Province who competed in the (CLRAA) in the 2019 – 2020 school year.	Agility : Shuttle run test. Speed : 50-meter test.	There is a significant relationship between agility and body mass index (p-value 0.009). There is a significant relationship between speed, agility and body mass index (p-value 0.000).
Thakur (2016)	Method: Descriptive statistics and the Pearson's Product Moment Correlation with Purposive Sampling. Sample (n): 45 male kabaddi athletes. Sample inclusion criteria : Members of various teams participating in the inter-university Kabaddi tournament (2015-16) held at BHUVaransi (U.P) who are aged 20 – 25 years and are in the Obesity BMI category.	Speed: 50 mt.dash calculated in seconds. Agility: 4x10m. shuttle run test is calculated in seconds.	There is a significant relationship between body mass index, speed, and agility ($p<0.05$).
Cinthuja *et al.,* (2015)	Method: Descriptive Study with Purposive. Sample (n): 183 badminton athletes (110 men and 73 women). Sample inclusion criteria : badminton athletes (6 boys schools and 5 girls schools) in the age category 9 - 15 years. Sample exclusion criteria: badminton athletes who have a history of sports that cause asthma, have other medical problems such as heart or lung disease, have musculoskeletal disorders, and have experienced an injury 3 months before the study.	Speed: 20m Sprint speed test. Agility: T Test (seconds)	There is a significant relationship between body mass index and agility in male athletes (p=0.001).
Wahono *et al.,* (2023)[8]	Method: Cross Sectional Sample (n): 36 athletes (18 men and 18 women) in East Java handball. Sample inclusion criteria: East Java handball athletes in the age range 18 – 23 years.	Agility : The Illinois Agility Test is calculated in minutes and seconds according to Illinois norms.	There is a significant relationship between BMI and agility in female athletes (p = 0.019).
Kamarudin *et al.,* (2022)	Method: Cross Sectional with MANOVA statistical analysis. Sample (n): 147 male athletes Sample inclusion criteria: male athletes participating in the Malaysian Games with an age range of 13–21 years and who have signed a written consent letter.	Speed: 20 meter sprint test is calculated in seconds. Agility: T test is calculated using the Brower Timing System.	There is a significant relationship with the independent variable, namely BMI for individual and team sports in the normal, overweight and underweight BMI categories.

CLRAA, Central Luzon Regional Athletic Association

Based on Kamarudin *et al.,* (2022)[17], showed that the Skill Related Fitness Component (SRFC) in the dependent variable speed was found to be (Pr>f = 0.000), which means there is a significant relationship with the independent variable,

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namely BMI for individual and team sports in the normal, overweight and underweight BMI categories. Based on the MANOVA results graph, it was found that individual and team sports in the normal, overweight and underweight BMI categories were positively correlated with speed. The same thing was also found in the dependent variable agility which was obtained (Pr>f = 0.011), which means that there was a significant relationship with the independent variable, namely BMI for individuals and team sports in the normal, overweight and underweight BMI categories. Based on the MANOVA results graph, it was found that individual and team sports in the normal, overweight and underweight BMI categories were positively correlated with agility.

Discussion

Agility and speed are one of the basic components that an athlete must have. Each sport will have different criteria for each athlete. Agility is a form of muscle coordination to carry out complex movements and change the direction of movement quickly, while speed is the body's ability to respond by producing a movement in the shortest possible time.[9] In a study, it was stated that there are several factors that influence agility, namely, strength. , muscle explosive power, balance, reaction speed, and coordination. Apart from that, there are other factors that can influence agility such as body type, age, gender and weight.[10]

For futsal athletes, it is explained that players must have a BMI that is in the normal category because if the player has a body weight that is in the overweight category, it will affect agility because being overweight makes movement slow.[11] Agility and fast running are two things that are needed to support The performance of soccer athletes is related to their function in neuromuscular control and lower limb biomechanics.[12] Speed is the ability to move in a short period of time with accurate movements. It is said that in soccer athletes, apart from movement speed in performing soccer techniques, running speed is also needed.[13] Meanwhile, in swimming athletes there is a significant relationship (p = 0.026) between body mass index and speed. It is said that the lower the BMI, the better the athlete's swimming speed. However, there are other factors that support an athlete's swimming speed, such as arm muscle strength.[14]

According to research from Thakur, it is explained that BMI which is included in the obesity category has a significant relationship with speed and agility. The components that make up BMI include body weight and height. It is also stated that the one most related to speed and agility is body weight.[15] Apart from that, it was also explained in research from Cinthuja, et al that there is a significant relationship between agility and speed and BMI but there are differences. p-value results for speed if also seen from the gender of the sample.[16] Based on other research from Kamaruddin, et al, it was found that there was a difference in the results between speed and agility from BMI in the underweight and overweight categories which explained that athletes who had a BMI in the underweight category had better agility and speed compared to athletes in the overweight BMI category because there are differences in their muscle mass.[17]

Based on other studies, it is said that athletes who run 400 m have superior height compared to athletes who run 100 m. Longer legs can reduce stride speed because the distance taken will be quite far, while relatively shorter legs will have a lower moment of inertia so they require less energy to accelerate. So it can be said that athletes who run the 100 m sprint have the advantage of having a lower BMI because they can have the ability to react in a short time.[7] A low BMI has a good influence on sports that have a main focus on aesthetics and body image, such as gymnastics and figure. skating. Athletes in this sport will maintain their BMI in the underweight category, which tends to be normal.[4]

Ballet dancing is one of the sports that most maintains the body weight of its athletes in the underweight category because ballet is a sport that is closely related to the categories of aesthetics, gravity and body weight. Ballet dancers are required to have agility in carrying out each movement and speed of reaction to the accompanying music so that having an underweight BMI category will make the ballet dancer's muscle mass low which will then provide an advantage to the athlete.[18]

As another example, the sport of wrestling will have a BMI in the obesity category, namely around 36.5 kg/m2 which will hinder agility due to high muscle mass because for wrestling athletes muscle mass is very important apart from performance and promotion to higher leagues. Increasing muscle mass has a positive effect on improving athlete performance, however increasing body fat can have a negative impact on athlete performance except for wrestling athletes and football linemen who require blocking ability more than agility to achieve the goals of these sports.[4]

Individuals with a BMI that is classified as obese tend to have a large body size, which results in slow and limited body movements. Individuals with obesity have a heavy body weight, resulting in a large burden on the knees to support the body. Based on research, individuals who are overweight tend to have slow movements and lack body flexibility when making movements, which affects agility. If the body weight is ideal, a person's agility will be better compared to having more weight because if the body weight is too excessive, it will cause imbalance and result in poor agility.[19]

Excessive body weight is associated with reduced player performance, excessive body weight will cause players to carry additional weight during the playing process, causing poor performance and ultimately reducing the player's agility, thereby reducing running speed.[20,21] Excess weight can directly reduce agility. One important factor that influences agility is speed. Someone who is overweight tends to have slow movements, this may be caused by the extra weight and lack of body

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flexibility when making movements. So if one of the factors of agility, namely speed, is not good, then directly a person's agility will also be bad.[22,23]

Based on several studies above, it was found that body condition in the underweight and overweight BMI categories does not always have a negative impact on athlete performance. In several sports, BMI is required in the appropriate category, whether underweight or overweight, to help achieve the goals of each sport. The weakness of this literature review is that it does not look at the age category of the athletes, the level of training given by the coach to the athletes, and the length of rest time between each competition that the athletes go through, which of course can influence the athletes' abilities and body composition.

The limitations of this study were not explained regarding the intervention to treat the problem, so there is a possibility of bias, and it cannot be generalized to all subjects. Future studies can explain the specifics of the intervention to treat the problem in subjects and their correlation between the body mass index, speed, and agility among athletes with quality of life.

Conclusion

Based on our literature review, there were possibly the relationships between BMI category, speed, and agility among the athletes. Athletes who were in the underweight BMI category would have better agility and speed compared to athletes who were in the overweight BMI category. Athletes have different BMI categories depending on the sport. Further research is needed that discusses the relationship between the level of training received by athletes, BMI, and other biomotor abilities to support athlete's performance.

Author Contribution

IALD conceived the study design and data collection and drafted the manuscript; AAGAPN and IGAA collected the data and revised the manuscript.

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Conflict of interest

The author states there is no potential conflict of interest in connection with the research, authorship and or publication of this article.

Ethical consideration

This review study used published articles that are accessible. Thus, this study did not require any informed or ethical consideration.

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