

Assessment of body weight in 14–15-year-old children and differences in dominant side and explosive force of upper extremities

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Abstract

Introduction- Overweight and obesity serve as barriers for children to engage in physical activity at the same level as their normal-weight peers. Various physiological factors, including body mass index (BMI), have been observed to affect explosive strength across different demographics. In turn, these factors are influenced by other physiological variables. However, the determinants of explosive strength vary among different demographics. **Methodology-** This study included 76 participants aged 14 to 15 years from high schools in the territory of Pristina. Participants were selected using random sampling. Data regarding BMI, gender, and explosive strength were collected. The collected data underwent linear regression analysis using SPSS software to address the research objectives. **Results-** The sample comprised 31 males and 45 females. Mean gender differences yielded nonsignificant results ($p = 0.108$). The average age of males was slightly higher than that of females, but this difference was not statistically significant ($p = 0.166$). Additionally, there was no significant disparity in body weight between the two sexes ($p = 0.066$). No significant differences were found in the distribution of subjects by BMI and sex ($p = 0.341$). Conversely, the study revealed a significant correlation between the subjects' BMI and the strength of their hand muscles ($p < 0.001$), implying that a higher BMI is associated with greater hand muscle strength. However, the subjects' BMI was not significantly correlated with the explosive strength of the upper extremity ($p = 0.127$). **Conclusion-** This obtained results lead to the conclusion that the BMI of adolescents aged 14–15 years is not influenced by gender. While BMI has a significant impact on the muscle strength of both hands, it does not affect the explosive strength of the upper extremity in the study population.

Keywords: BMI, Gender, Dominate Side, Handgrip

Introduction

Physiological factors play an important role in the performance of people of all ages across different sports, including football, and basketball. Such factors, including muscle mass, strength, and body weight not only influence the overall fitness and sports performance of an individual but are also associated with individual components of sports-related movement (Vladimir Vladimirovich, 2022). A vast amount of research has been undertaken by contemporary researchers to identify and analyse the physiological factors that influence the performance of players in different sports, as well as their risk of injuries in these sports (Den Hartigh et al., 2022; Ferrandez et al., 2021). Such research helps determine the factors or attributes related to the physical features of an individual or player that need to be considered during their training, and evaluation, also designing prevention and treatment interventions for injuries.

Contemporary literature shows that body weight and muscle strength influence several important aspects of a player's motor skills in various populations and sports (Uzunović et al., 2019; Xu et al., 2020). One such important factor is the explosive strength of the upper extremities. It determines the level of strength in the upper extremity that helps produce explosiveness in the upper extremity, which in turn is defined as the ability to produce maximum strength in minimum time (Diker et al., 2021).

This motor skill significantly influences the performance of individuals in several sports, including sprinting, basketball, and football (Diker et al., 2021; Seipp et al., 2022). Several physiological factors have been observed to influence the explosive strength of individuals. For one, in general, muscle strength is positively correlated to explosive strength (Behm et al., 2017; Takanashi et al., 2020). Some authors (Usgu et al., 2021) investigated the influence of BMI on several viscoelastic properties of muscles in both normal and overweight individuals. The researchers found that BMI increases the stiffness of upper extremity muscles, especially the biceps. Moreover, other authors (Usgu et al., 2021) also observed that increased BMI is associated with a reduction in muscle elasticity in the upper extremity. Meanwhile, muscle elasticity is significantly associated

with explosive strength. At the same time, gender has also been observed to influence the BMI of individuals in different demographics. For example, (Muhammad et al., 2022) in their study involving older adults, analyzed the association between gender and the prevalence of BMI-based obesity.

The researchers found that the prevalence of obesity is significantly higher in older women in India (26.3%) than in older men in the country (17.6%). Meanwhile, the present study implies that gender does not influence the prevalence of BMI-based obesity among adolescents in this study.

Studies have shown that weighting, which is also defined as overweight, and obesity is a barrier for children to perform the same level of physical activities as normal-weight children (Riddiford-Harland et al., 2006). This statement has been supported by other authors who claim that even underweight children perform better in terms of explosive power compared to overweight and obese children who show slightly different values from the normal weight population (Castro-pin et al., 2009).

In addition, there is clear evidence that foot explosive power is related to the overall level of strength in children (Malina et al., 1995). In a study published by (Belmonte Gonzalez-Suarez & Grimmer-Somers, 2011) it appeared that being overweight, and especially obese, impairs speed running and jumping distance compared to a normal weight of adolescent individuals. Unchangeably for children, many recent data show that even overweight and obese adolescents had lower levels of physical fitness compared to their normal counterparts (Shah et al., 2020; Theo Nikolaidis, 2013), they also analyzed the statistical association between gender and obesity among children and adolescents aged 5-19 years.

Notably, the sample of this study included subjects from several high and middle-income countries. Therefore, the findings of this study can be presumed to be globally generalizable. Based on the analysis, the researchers found that the prevalence of obesity is higher among boys aged 5-19 years than in girls belonging to the same age group.

This study aims to determine the associations among gender, muscle strength, and explosive strength in children. Based on the findings of this study, coaches and training institutes can devise better sports training programs for children. Moreover, the findings may also produce viable empirical evidence for making national policies for improvement in the overall fitness and sports-related performance of children to produce lifelong benefits to their health.

Methodology

This research was conducted during the year 2023, including 76 children of the age group of 14-15 years from two high schools within the region of Pristina, Kosovo. As such, the sample of this study consists of adolescents from a narrow age group (Sharma et al., 2019). The selection criteria involve children living within the set region, being of the set age and being willing to participate in the study (them and their legal guardians/parents). Children and their legal guardians/parents were notified in advance, within one prior set meeting, whereas participation consent was signed.

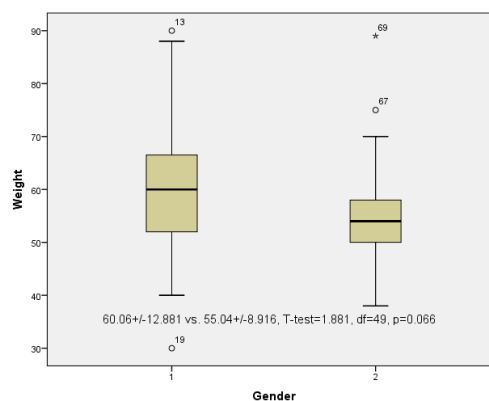
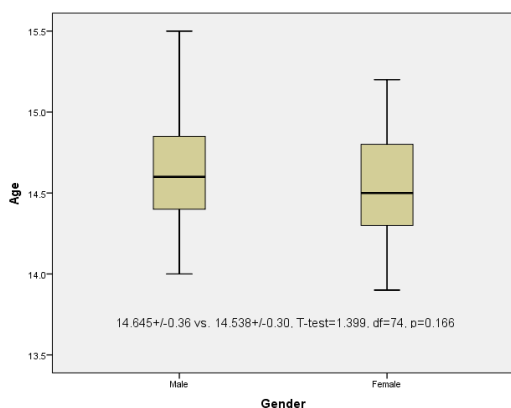
The selection process was done in a random manner, in between the classrooms of the planned schools that were divided proportionally between urban and rural parts of the region. Age (ratio scale) was determined based on the statement from the subject designated for testing, gender, and dominant side (nominal scale), while anthropometric measurements was done by estimating the subject in their height (ratio scale) and body weight (ratio scale), BMI (ratio) was calculated using the formula proposed by Quetelet ($BMI = \text{body mass (kg)} / \text{foot height cm}^2$) (Fatikasari et al., 2021). And subjects were classified as underweight, normal weight, overweight, and obese using the points presented by (Cole et al., 2000). The strength of the hands was measured in both handgrip (ordinal scale) (Leonardo Mechanograph, Germany), and the explosive power (ordinal scale) was evaluated with Medicine Ball from 3kg where the subject did the throw from the knee position, then the throw length was evaluated.

Statistical analysis

The data were summarized following mean and standard deviation for continuous variables and relative frequencies for categorical variables. Differences between groups and genders were tested by the Independent-Samples T-test, and the association between variables was assessed through linear regression analysis using the SPSS software (Zou et al., 2019).

Results

In the study, we included a total of 31 males and 45 females. The sample mean age of males was slightly higher than the sample mean age of females, but the difference was not significant (14.645 ± 0.36 vs. 14.538 ± 0.30 , T-test = 1.399, df = 74, p = 0.166) (Graph.1). The sample mean of body weight of males was slightly higher than the sample mean of females, but without significant difference (60.06 ± 12.881 vs. 55.04 ± 8.916 , T-test = 1.881, df = 49, p = 0.066) (Graph.2).



Graph 1. Descriptive data for the age of subjects included in the study.

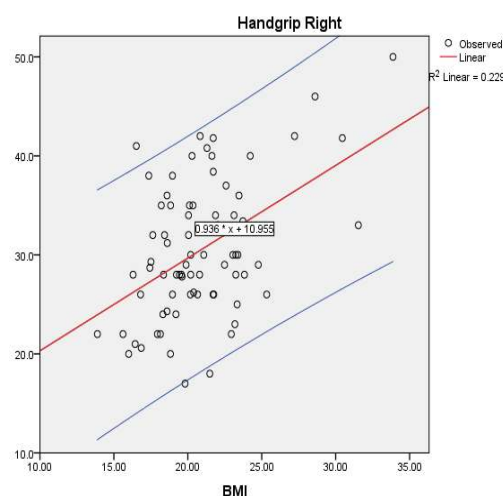
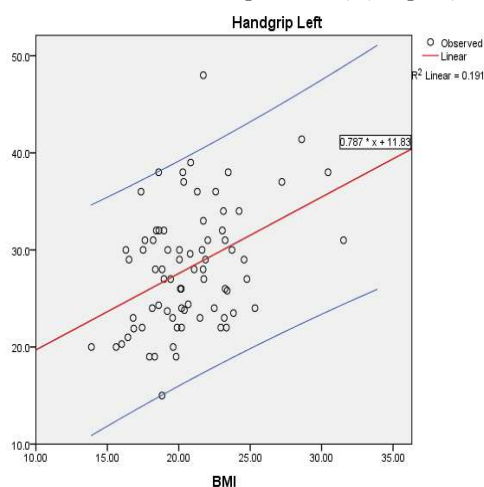
Graph 2. Descriptive data for the weight of subjects included in the study.

We did not have a significant difference in the distribution of subjects according to BMI category (Underweight M-10, F-8; Normal weight M-18, F-34; Overweight and Obese M-3, F-3) and their sex (Chi-test = 3.347, df = 3, p = 0.341).

Table 1. Descriptive all data

	Total ±	Male ±	Female ±
Age	14.5 (14.3 – 14.8)	14.6 (14.4 – 14.9)	14.5 (14.3 – 14.8)
Weight	55.5 (50.2 – 62.0)	60. (52.0 – 67.0)	54.0 (49.5 – 58.5)
Height	1.6 (1.6 – 1.7)	31.0 (28.0 – 38.0)	24.3 (22.5 – 30.0)
Handgrip left	28.0 (23.1 – 32.0)	31.0 (28.0 – 38.0)	24.3 (22.5 – 30.0)
Handgrip right	29.1 (26.0 – 35.0)	35.0 (29.3 – 40.0)	28.0 (24.1 – 30.0)
Medicine ball	3.5 (3.2 – 4.5)	4.7 (4.4 – 5.3)	3.2 (3.0 – 3.4)
BMI	20.2 (18.6 – 23.0)	20.1 (17.9 – 22.6)	20.4 (18.9 – 23.1)

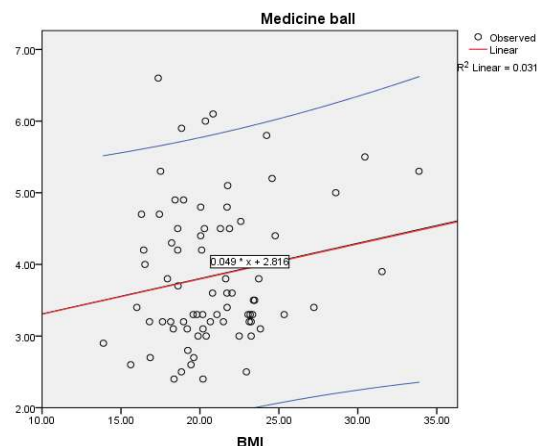
According to the logical regression analysis, where a dependent variable was a representation of overweight or obesity, while as an independent variable, we took the sex of subjects (with reference code = 1 for males and 2 for females), we found that in females the likelihood of developing overweight or obesity was reduced insignificantly by a factor of 0.667 (OR = 0.667, 95% CI 0.125 to 3.542, df = 1, p = 0.634). The equation with which Logit (P) is calculated for the occurrence of overweight or obesity depending on the sex of the subject was: $\text{Logit}(P) = -1.828 - (2.234 * \text{Gender})$. In the model of logical regression analysis with the reference code for women (RC-2), according to which for the female sex we get the value one (1) and for the male sex we get the value zero (0), the Logit equation (P) for the representation of overweight or obesity by sex is: $\text{Logit}(P) = -2.234 - (0.405 * \text{RC-2})$. According to these results, we found that sex is not a factor with a significant impact on the likelihood of overweight or obesity (OR = 0.667, 95% CI 0.125 to 3.542, df = 1, p = 0.634). The regression analysis found a significant correlation between the strength of the left-hand muscle and BMI values ($R = 0.437$, $R^2 = 0.191$, t-test = 4.185, $F = 17.513$, $p < 0.0001$) (Graph.3). The findings suggest a significant correlation between the strength of the right-hand muscle and BMI values ($R = 0.478$, $R^2 = 0.229$, t-test = 4.685, $F = 21.95$, $p < 0.0001$) (Graph.4).



Graph 3. Regression analysis for handgrip left and BMI values for the subjects included in the study.

Graph 4. Regression analysis for handgrip right and BMI values for the subjects included in the study.

According to the linear regression analysis, we did not find a significant correlation between muscle explosive force and BMI values ($R = 0.177$, $R^2 = 0.031$, $t\text{-test} = 1.545$, $F = 2.386$, $p = 0.127$) (model summary ANOVA) (Graph.5).



Graph 5. Regression analysis for Medicine ball and BMI values for the subjects included in the study.

Discussion

A total of 76 adolescents were included in this study, of which 31 were males and 45 were females, based on the findings between genders there was no significant difference $p=0.108$. Age of the participants ranged between 13-15 years. The average age of the sample was 14 years 6 months (± 4 months). The significance of the correlations have been determined based on the p -values deduced from linear regression (Di Leo & Sardanelli, 2020). The average age in males was slightly higher than in females but by no significant difference, $p=0.166$. Also, the body weight between the two genders has no significant difference $p=0.066$. We did not have a significant difference in the distribution of subjects by BMI category and their gender $p=0.341$. According to the results, we found that gender was not a factor with a significant impact on the likelihood of overweight or obesity $OR=0.667$, 95% CI 0.125 to 3.542, $df=1$, $p=0.634$.

This finding is significant when considered against the existing body of literature. Contemporary researchers have proven a significant statistical association between gender and obesity for both older adults and children. For example, in their study involving older adults, (Muhammad et al., 2022) analysed the association between gender and the prevalence of BMI-based obesity. The researchers found that the prevalence of obesity is significantly higher in older women in India (26.3%) than in older men in the country (17.6%). Meanwhile, the present study implies that gender does not influence the prevalence of BMI-based obesity among adolescents in this study. Thus, by contrasting the findings of the present study to the findings of (Muhammad et al., 2022), it can be concluded that the association between gender and obesity changes with age. In other words, it can be hypothesized that the influence of gender on the prevalence of obesity increases with an increase in age. However, to produce empirical evidence in support of this association, as well as to understand the nature of this change in the association between gender and obesity with age, further primary research is necessary.

Moreover, the findings of this study also contradict the findings of (Shah et al., 2020), who found the association between gender and obesity to be significant among children (5-19 years). However, it must be noted that the age range of the sample in the study of (Shah et al., 2020), was significantly wider than that of the present study. Considering this fact, a potential reason behind the contradiction between the findings of the present study and those of (Shah et al., 2020), can be deduced. It is possible that the association between gender and the prevalence of obesity is insignificant specifically among adolescents. The present study found a significant correlation between the strength of the left-hand muscle and the BMI values $R=0.437$, $R^2=0.191$, $t\text{-test}=4.185$, $F=17.513$, $p<0.0001$. As per the findings of linear regression analysis, we found a significant correlation between the strength of the right-hand muscle and BMI values $R=0.478$, $R^2=0.229$, $t\text{-test}=4.685$, $F=21.95$, $p<0.0001$.

This finding somewhat aligns with the findings of other contemporary researchers. For example, in a cross-sectional study, (Hardy et al., 2013) attempted to analyse the association between BMI and muscle strength. The researchers found that a higher BMI is negatively associated with the strength of lower extremity muscles but is positively associated with the strength of hand muscles, especially in men. The latter finding somewhat aligns with the findings of the present study. However, it must be noted that the sample studied by (Hardy et al., 2013) consisted of older adults, whereas the present study has focused solely on adolescents. On the other hand, (Hasan et al., 2016) studied the relationship between BMI and muscle strength. Based on the findings of statistical analysis, the researchers concluded that children with higher BMI demonstrate relatively higher levels of muscle strength, which supports the finding of the present study that BMI is positively associated with the strength of hand muscles.

There was also a slight change in handgrip strength for boys and girls that was lower in overweight/obese adolescents. These results are consistent with recent data published by other authors (Rauch et al., 2012), but different from the results of other publications (Gulías-González et al., 2014; Tomaszewski et al., 2007).

Although (Hardy et al., 2013) did not differentiate between the muscles in the upper and lower extremities, while interpreting the findings, the researchers cited previous studies that had also implied that higher BMI is positively associated with the strength of upper extremity muscles. A possible explanation of the positive association between BMI and muscle strength in the upper extremity has been provided by (Tomlinson et al., 2016). Citing other studies, the researchers stated that the contemporary body of literature has a consensus that obese individuals demonstrate higher absolute maximum muscle strength than their non-obese counterparts. To explain this phenomenon, the researchers hypothesized that increased adiposity, which is the cause of obesity, acts as a “chronic overload stimulus on the antigravity muscles” (Tomlinson et al., 2016). Moreover, the researchers also suggested that higher BMI can potentially influence the architecture of muscles, creating higher strength in the upper extremity muscles, including those in the hands. This study did not find a significant correlation between the explosive muscle strength and BMI values $R=0.177$, $R^2=0.031$, $t\text{-test}=1.545$, $F=2.386$, $p=0.127$. This finding is even more significant when because higher BMI positively influences the strength of upper extremity muscles in the study population.

Considering the findings of (Behm et al., 2017), it can be deduced that higher BMI, which is associated with increased strength of the upper extremity muscles, should also be positively associated with the upper extremity explosive force of individuals. However, a more in-depth analysis of this finding considering additional literature provides a more comprehensive understanding of the negative association between BMI and upper extremity explosive force, as well as the underlying factors of this association. From the findings of (Usgu et al., 2021), it is intuitive that a higher muscle elasticity increases explosive strength, whereas higher stiffness of muscles decreases explosive strength (Maciejewska-Skrendo et al., 2020). Based on this fact, it can be deduced that higher BMI, which causes low muscle elasticity, effectively reduces the explosive strength of adolescents. Moreover, it can be inferred that the negative influence of BMI on muscle elasticity is greater than the positive influence of BMI on muscle strength of the upper extremity, which leads to the negation of any positive impacts of higher BMI on explosive strength. Based on this deduction, the lack of significance of the correlation between BMI and the explosive strength of the upper extremity can be justified.

Limitations

Based on the findings discussed above, it can be stated that the present study has successfully addressed the underlying research aim. However, the study is also associated with several potential limitations that might have affected the validity and generalisability of the results. One of these potential limitations is the small sample size. Due to time and resource constraints, the study included a sample of 76 adolescents. However, considering the vast population of adolescents worldwide, it is possible that the sample of this study is too small to produce generalizable results for this population (Varoquaux, 2018). Moreover, the age range of the sample of this study was extremely narrow. While the adolescence period ranges between 10 to 19 years of age, the present study included participants who were aged between 14 and 15 years. This extremely narrow age range potentially excluded individuals who might have represented significant proportions of adolescents. Therefore, the narrow age range of the sample might also have affected the validity of the findings of this study to the global population of adolescents (Stuart et al., 2018).

Conclusion

The aim of this study was to analyze the correlations between gender, BMI, muscle strength, and explosive strength in the upper extremity of adolescents. According to the results, we can conclude that this study has found a significant and positive correlation between BMI and upper extremity muscle strength. At the same time, the study has proven that gender is not associated with the prevalence of obesity among adolescents. Similarly, BMI has not been found to have any statistically significant correlation with the explosive strength of the upper extremity in adolescents. In summary, the current study has been in line with the current state of the art within the field, while having shown that there were small differences between boys and girls in general, and thus with gender not being a factor in the occurrence of overweight and obesity. Moreover, being overweight has a small negative impact on physical fitness being more dominant. In conclusion, our study confirmed already published data about differences between boys and girls concerning physical fitness and anthropometric data. It could be shown that there is a weak correlation between physical fitness and body composition.

However, body composition and physical performance must be considered independent from each other in terms of health risks for example a higher handgrip strength (to be regarded as positive) is associated with higher body mass (to be regarded as a negative health factor). However, it should be noted that the findings of this study might have been influenced by the limitations of the small sample size and the narrow age range of the participants. To overcome these limitations, further research is necessary. Moreover, it is also recommended that future researchers conduct primary research to understand how BMI is influenced by gender throughout different ages. This will help explain why BMI is associated with gender in older adults and children, but not in

adolescents. Moreover, future researchers should also replicate this study on a global scale and involve participants aged 10-19 years to ensure the validity and generalizability of the results for the global population of adolescents.

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Institutional Review Board Statement: The Ethics Committee of the Chamber of Physiotherapy gave its approval after the study was carried out in accordance with the Declaration of Helsinki.

Informed Consent Statement: All participants in the study provided their informed permission. Written informed consent has been obtained from the patient(s) to publish this paper.

Data Availability Statement: On request, the corresponding author will provide access to the data used in this work.

Conflict of interest: The authors declare no conflict of interest.

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