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PHYSICAL EDUCATION OF STUDENTS

ORIGINAL ARTICLE

# The effect of three different sets method used in resistance training on hypertrophy and maximal strenght changes

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**Abstract**

*Background and Study Aim* To compare the effects of three different sets method, which is frequently used in resistance training, on strength and hypertrophy values.

*Material and Methods* Thirty-three young male athletes with similar daily activities and nutrient intakes at the Fitlife fitness center in Sakarya were included in the study. Participants were randomly divided into three different groups as Modified German Volume Training (MGVT) (n=11, 21.5 ± 2.4 years), Super Set (SS) (n=11, 22.4 ± 2.9) and Giant Set (GS) (n=11, 23.0 ± 4.3 years). The study was started with a total of thirty-three people, but two participants in the Giant set group were excluded from the measurements because they left the study due to personal reasons. Strength, muscle thickness and cross-sectional area (CSA) measurements were made in the upper extremity muscles before and after the six-week training period.

*Results* After six weeks of training, significant increases were observed in the cross-sectional area and thickness ($p<0.05$) of pectoralis major, deltoid, and latissimus dorsi muscle groups in all three groups, and in the strength parameter ($p<0.05$) in bench press, barbell row and shoulder press exercises. There was no difference in strength, muscle cross-sectional area and thickness parameters between the groups ($p>0,05$).

*Conclusions* Modified German Volume Training (MGVT), Super Set (SS) and Giant Set (GS) methods reveal that there is no difference between the set methods in the 1 Repetition Maximum (1RM) strength and hypertrophy development of young male individuals who do not have a history of resistance exercise but have completed the adaptation period, and that there is an improvement in all set methods.

**Keywords**: muscle hypertrophy, strength, muscle thickness, cross-sectional area

## Introduction

Resistance training is proven to increase lean body mass, strength, and power (ie hypertrophy). Nevertheless, it was found that it can enhance physical performance (such as jump height), which can support sporting outcomes [1]. However, many people practice resistance exercises because of their effectiveness in increasing muscle mass and strength [2]. Various methods are used in a training routine to maximize efficiency in resistance training [3, 4]. Manipulation of the various acute variables used by trainers and athletes (e.g., intensity, volume, exercise selection and sequence, time under tension and rest interval) provides increased efficiency in muscle mass gain and avoids entering a plateau phase [5].

German Volume, Superset, and Giant Set techniques are the most popular among these resistance training approaches. German Volume Training (GVT) is a technique that national weightlifting coaches employ to build their athletes' muscle mass off-season [6]. A GVT session traditionally involves performing 10 sets of 10 repetitions for one core compound resistance exercise, and this method uses up to two core compound exercises in one training session [7]. In order to achieve high training volume while applying the sets, it is performed at intervals of 1-20 repetitions with loads of around 60% of 1RM, and the resting time between sets is relatively shorter (60-90 seconds) to compared to a strength training program increase metabolic stress (e.g., lactate) [6]. The "superset" method, on the other hand, includes varying the amount of time between sets or exercises for the same muscle area as a means of boosting training intensity. This environment accepts the validity of "superset", which groups exercises targeting the same muscle area, to increase exercise intensity [8, 9, 10]. One of the methods used to increase metabolic stress is the Giant Set method. The Giant Set method involves performing two or more exercises that appeal to the same muscle group without any pause between them [11]. Increasing the levels of mechanical strain


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and metabolic stress, these strategies can trigger the activation of factors presumed to be involved in anabolism, such as improvement in hormonal activities, increase in protein synthesis and muscle fiber diameter, and muscle swelling, and induce muscle hypertrophy [12].

When the current literature investigating the effects of these three sets method is examined, it is seen that authors [2, 6] compared GVT and Modified German Volume Training (MGVT) methods in their studies. While the GVT method includes 10 sets of 10 repetitions, MGVT includes 5 sets of 10 repetitions, and when the results of these studies are examined, it was determined that the ideal number of sets for muscle mass and strength development is in the range of 4-6 sets. Brentano et al. [8] and Kelleher et al. [13] compared superset and traditional resistance training methods in their studies. When the results were examined, it was observed that the superset method caused more metabolic stress and muscle damage. However, it is known that more metabolic stress and muscle damage will contribute positively to the development of hypertrophy. Fink et al. [12] compared superset and traditional resistance training methods in his study. When the results were examined, improvements were observed in both groups in muscle thickness and muscle cross-sectional area, but no difference could be detected between the groups.

In such studies, it is seen that training experience can positively affect the stimulation of the targeted muscles. Compared to other athletes, bodybuilders have a unique sensitivity to focusing on metabolic stimuli [14] and muscle stimulation [15].

The aim of this study is to compare the effects of three different sets method, which is frequently used in resistance training, on strength and hypertrophy values, and in this context, there is no study comparing the effects of these three sets method when the literature is examined. We think that this research will contribute to enrich the literature on training variables and to give a different perspective to this field.

## Materials and Methods

*Participants*

Thirty-three young male athletes with similar daily activities and nutrient intakes at the Fitlife fitness center in Sakarya were included in the study. Participants were randomly divided into three different groups as Modified German Volume (n=11, 21.5 ± 2.4 years), Super Set (n=11, 22.4 ± 2.9) and Giant Set (n=11, 23.0 ± 4.3 years). The study was started with a total of thirty-three people, but two participants in the Giant set group were excluded from the measurements because they left the study due to personal reasons. Eligibility criteria are that the participants should be between the ages of 18-27, practice regular exercise, do not use smoking and alcohol, do not take drugs that will affect their blood levels and performance, have no health problems, and have at least 1 month of resistance training adaptation. The experiment was conducted during the period between midterm exams, as most of the participants were students, and during this time the participants were asked to avoid physical activities outside the training program. All participants were informed about the possible risks of the experiment and their written consent was obtained to participate in the experiment. This study was approved by the Ethics Committee of Sakarya University of Applied Sciences (100/2184) and was performed in accordance with the Declaration of Helsinki International Standards for Human Research. All data were collected at the Campus Fit life gym in Sakarya.

*Research Design*

*Resistance Training*

The exercise program was applied 3 days a week for 6 weeks. There are 3 different groups in the study. A regional (split) program was applied to the groups in the form of chest on the first training day of the week, back on the second training day, and shoulders on the third training day. The resistance training program is given in Table 1. The MGVT method was applied to the first group. In this method, the first 2 movements of the training program were selected from compound exercises and 5 sets of 10 repetitions were applied, and additional exercises were added to these exercises. In the MGVT method, the rest period between sets was 90 seconds [2]. Superset method was applied to the second group. This method was applied one after the other without giving a rest period between 2 exercises for the same muscle group and the whole training program was applied in the same order. In the superset method, the rest period between sets was 60 seconds. Giant set method was applied to the third group. In this method, 4 exercises for the same muscle group were applied one after the other without resting between them. In the giant set method, a rest period of 60 seconds was applied between sets. In the study, training intensity was applied between 60% and 80% of the subjects' maximal weight. In the first week of the study, the training was started with 60% intensity and the principle of progressive overload was applied by increasing the intensity by 5% every week.

*Total Training Volume*

In order to equalize the training coverage of all participants, the same number of exercises, sets and repetitions were applied in total for a training session. Exercise intensity was applied between 60% and 80% of the participants' 1RM values, and the intensity was equalized.

*Measurement*

**Table 1.** Resistance Training Program

| Variables | Set | Repetition | Resting, sec. | Exercise intensity, % |
|---|---|---|---|---|
| **Modified German Volume Training** | | | | |
| 1st Day | | | | |
| Bench Press | 5 | 10 | 90-120 | 60-80 |
| Incline Bench Press | 5 | 10 | 90-120 | 60-80 |
| Decline D Press | 3 | 12 | 90-120 | 60-80 |
| Dumbbell fly | 3 | 12 | 90-120 | 60-80 |
| 2nd Day | | | | |
| Barbell Row | 5 | 10 | 90-120 | 60-80 |
| Lat Pull Down | 5 | 10 | 90-120 | 60-80 |
| Seated Row | 3 | 12 | 90-120 | 60-80 |
| Low Row | 3 | 12 | 90-120 | 60-80 |
| 3rd Day | | | | |
| Shoulder press | 5 | 10 | 90-120 | 60-80 |
| Dumbbell Front Raise | 5 | 10 | 90-120 | 60-80 |
| Lateral raise | 3 | 12 | 90-120 | 60-80 |
| Rear delt raise | 3 | 12 | 90-120 | 60-80 |
| **Superset** | | | | |
| 1st Day | | | | |
| Bench Press | 4 | 10 | 60 | 60-80 |
| Dumbbell fly | 4 | 10 | 60 | 60-80 |
| Incline Bench Press | 4 | 12 | 60 | 60-80 |
| Decline Dumbbell Press | 4 | 12 | 60 | 60-80 |
| 2nd Day | | | | |
| Barbell Row | 4 | 10 | 60 | 60-80 |
| Low Row | 4 | 10 | 60 | 60-80 |
| Lat Pull Down | 4 | 12 | 60 | 60-80 |
| Seated Row | 4 | 12 | 60 | 60-80 |
| 3rd Day | | | | |
| Shoulder press | 4 | 10 | 60 | 60-80 |
| Dumbbell Lateral Raise | 4 | 10 | 60 | 60-80 |
| Dumbbell Front Raise | 4 | 12 | 60 | 60-80 |
| Rear Delt Raise | 4 | 12 | 60 | 60-80 |
| **Giant set** | | | | |
| 1st Day | | | | |
| Bench Press | 4 | 10 | 60 | 60-80 |
| Incline Bench Press | 4 | 10 | 60 | 60-80 |
| Decline Dumbbell Press | 4 | 12 | 60 | 60-80 |
| Dumbbell Fly | 4 | 12 | 60 | 60-80 |
| 2nd Day | | | | |
| Barbell Row | 4 | 10 | 60 | 60-80 |
| Lat Pull Down | 4 | 10 | 60 | 60-80 |
| Seated Row | 4 | 12 | 60 | 60-80 |
| Low Row | 4 | 12 | 60 | 60-80 |
| 3rd Day | | | | |
| Shoulder Press | 4 | 10 | 60 | 60-80 |
| Dumbbell Front Raise | 4 | 10 | 60 | 60-80 |
| Lateral Raise | 4 | 12 | 60 | 60-80 |
| Rear Delt Raise | 4 | 12 | 60 | 60-80 |

In order to measure the changes in chronic muscle strength and hypertrophy caused by the three different sets method we used in the study, 1RM strength, muscle CSA and muscle thickness measurements were made before and after the 6-week training period.

*Body Composition*

Height measurements of the participants were made only while wearing shorts, with their heads straight, knees bent, and body straight. Body mass and body mass index data were collected with the Tanita bioelectrical impedance instrument (Tanita, Body Composition Analyzer, BC-418) connected to the bioelectrical impedance method.

*Maximal Strength Assessments*

1RM test was taken in bench press, shoulder press, barbell row exercises in the 1-week period before starting the training program. While taking the measurements, the measurements of each exercise were taken on different days and with 1 day of rest between them.

Before 1RM strength tests the athletes performed a standard 10-minute warm-up protocol on the bicycle ergometer. Immediately after, they performed dynamic mobility exercises for the upper extremity muscles. While performing 1RM strength measurements, 1 retest protocol recommended by the American College of Sports Medicine (ACSM) was applied. First, 2 warm-up sets of light to moderate were applied. After the first set was performed 5-10 repetitions, 1 minute rest was given. The second set was performed 2-5 repetitions and 2 minutes of rest were given. With the third set, 1 repetition attempt was started and 2-4 minutes of rest was given. In the following sets, 5-10% load increase was continued with each successful lift and a rest period of 2-4 minutes was given. When an unsuccessful lift occurred, the load was reduced by 2.5-5% and the lift was performed again [16].

*Muscle Thickness and Muscle CSA Measurements*

An ultrasound device (TOSHIBA Aplio 400) was used to measure the muscle cross-sectional areas and muscle thickness of the subjects. Shown in figure 1. [17], stated in his study that the ultrasound method used for hypertrophy measurements is the gold standard. In the study, measurements of pectoralis major, deltoid and latissimus dorsi muscles were taken. Measurement of the Pectoralis Major muscle group was taken from the region between the third and fourth ribs below the midpoint of the clavicle. The deltoid muscle group was measured as one-fourth of the distance from the acromion to the lateral epicondyle. In the Latissimus Dorsi muscle group, measurements were taken from the lateral side of the scapula.

*Statistical Analyses*

3*2 Repeated Measures ANOVA was applied to compare the pre-test and post-test data of the variables according to the groups. SPSS.21 program was used in the analysis of the data.

## Results

When examined the Table 2, it was determined that the averages of pec major thickness values in the pre-test and post-test showed a statistical difference ($p<0.05$). Accordingly, it was determined that the pec major thickness values increased between the pre-test and the post-test. In addition, it was determined that the pec major thickness values did not show a statistical difference according to the groups ($p>0.05$).

When examined the Table 3, it was determined that the averages of the deltoid thickness values in the pre-test and post-test showed a statistical difference ($p<0.05$). Accordingly, it was determined that the deltoid thickness values increased between the pre-test and the post-test. In addition, it was determined that the deltoid thickness values did not differ statistically according to the groups ($p>0.05$).

When examined the Table 4, it was determined that the averages of the latissimus thickness value in the pre-test and post-test showed a statistical difference ($p<0.05$). Accordingly, it was determined that the latissimus thickness values increased between the pre-test and the post-test. In addition, it

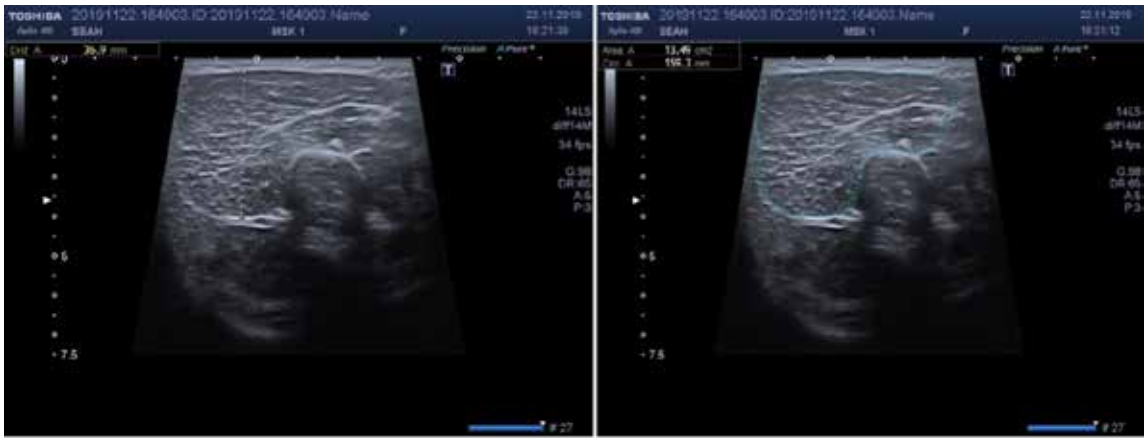

**Figure 1.** Muscle Thickness and CSA Measurements

was determined that the latissimus thickness values did not show a statistical difference according to the groups (p>0.05).

According to Table 5, it was determined that the averages of the pec major area values in the pre-test and post-test showed a statistical difference (p<0.05). Accordingly, it was determined that the pec major area values increased between the pre-test and the post-test. In addition, it was determined that the pec major area values did not differ statistically according to the groups. (p>0.05).

According to Table 6, it was determined that the averages of the deltoid area values in the pre-test and the post-test showed a statistical difference (p<0.05). Accordingly, it was determined that the deltoid area values increased between the pre-test and the post-test. In addition, it was determined that the deltoid area values did not differ statistically according to the groups. (p>0.05).

Considering Table 7, it was determined that the averages of the latissimus area value in the pre-test and the post-test showed a statistical difference (p<0.05). Accordingly, it was determined that the latissimus area values increased between

**Table 2.** Pre-test and post-test comparison of pec major thickness values of the groups

| Variables | N | Pre-test | Post- test | F | p |
|---|---|---|---|---|---|
| | | X̄ ± SD | X̄ ± SD | | |
| Modified German Volume Training | 11 | 2.60±0.49 | 3.51±0.57 | | |
| Super Set | 11 | 2.15±0.49 | 3.10±0.52 | 2.262 | 0.123 |
| Giant Set | 9 | 2.49±0.56 | 3.70±0.98 | | |
| Total | 31 | 2.41±0.56 | 3.42±0.72 | | |
| | | F=112.510; p=0.001 | | | |

**Table 3.** Pre-test and post-test comparison of deltoid thickness values of the groups

| Variables | N | Pre-test | Post- test | F | p |
|---|---|---|---|---|---|
| | | X̄ ± SD | X̄ ± SD | | |
| Modified German Volume Training | 11 | 2.68±0.37 | 3.32±0.31 | | |
| Super Set | 11 | 2.66±0.45 | 3.11±0.42 | 0.346 | 0.711 |
| Giant Set | 9 | 2.67±0.58 | 3.09±0.34 | | |
| Total | 31 | 2.67±0.45 | 3.18±0.36 | | |
| | | F=63.324; p=0.001 | | | |

**Table 4.** Pre-test and post-test comparison of latissimus dorsi thickness values of the groups

| Variables | N | Pre-test | Post- test | F | p |
|---|---|---|---|---|---|
| | | X̄ ± SD | X̄ ± SD | | |
| Modified German Volume Training | 11 | 4.19±1.10 | 4.58±1.06 | | |
| Super Set | 11 | 3.77±0.88 | 4.21±0.88 | 0.566 | 0.574 |
| Giant Set | 9 | 3.87±0.80 | 4.40±0.85 | | |
| Total | 31 | 3.95±0.93 | 4.40±0.92 | | |
| | | F=12.005; p=0.002 | | | |

**Table 5.** Pre-test and post-test comparison of pec major area values of the groups

| Variables | N | Pre-test | Post- test | F | p |
|---|---|---|---|---|---|
| | | X̄ ± SD | X̄ ± SD | | |
| Modified German Volume Training | 11 | 12.34±2.63 | 19.51±2.77 | | |
| Super Set | 11 | 10.28±2.93 | 17.38±2.42 | 1.463 | 0.249 |
| Giant Set | 9 | 12.10±3.83 | 20.20±7.41 | | |
| Total | 31 | 11.54±3.16 | 18.95±4.55 | | |
| | | F=128.860; p=0.001 | | | |

the pre-test and the post-test. In addition, it was determined that the latissimus area values did not show a statistical difference according to the groups (p>0.05).

Considering Table 8, it was determined that the averages of the pre-test and the post-test bench press values differed statistically (p<0.05). Accordingly, it was determined that the bench press values increased between the pre-test and the post-test. In addition, it was determined that bench press values did not differ statistically according to the groups (p>0.05). Also, it was revealed that the group*time interaction was statistically significant (F=4.383; p=0.022). Accordingly, it was determined that the increase in bench press values in the GS group was less than the increase in the bench press values of the other groups.

When examined the Table 9, it was determined that the averages of the barbell row value in the pre-test and post-test showed a statistical difference (p<0.05). Accordingly, it was determined that the barbell row values increased between the pre-test and the post-test. In addition, it was determined that the barbell row values did not differ statistically

**Table 6.** Pre-test and post-test comparison of deltoid area values of the groups

| Variables | N | Pre-test | Post- test | F | p |
|---|---|---|---|---|---|
| | | X̄ ± SD | X̄ ± SD | | |
| Modified German Volume Training | 11 | 14.61±3.10 | 16.15±1.71 | | |
| Super Set | 11 | 13.29±2.28 | 15.92±2.68 | 0.380 | 0.687 |
| Giant Set | 9 | 14.54±2.38 | 15.60±2.18 | | |
| Total | 31 | 14.12±2.61 | 15.91±2.16 | | |
| | | F=15.246; p=0.001 | | | |

**Table 7.** Pre-test and post-test comparison of the latissimus area values of the groups

| Variables | N | Pre-test | Post- test | F | p |
|---|---|---|---|---|---|
| | | X̄ ± SD | X̄ ± SD | | |
| Modified German Volume Training | 11 | 19.61±4.36 | 22.94±5.77 | | |
| Super Set | 11 | 17.26±4.45 | 22.95±7.12 | 0.210 | 0.812 |
| Giant Set | 9 | 17.03±3.51 | 23.24±5.92 | | |
| Total | 31 | 18.03±4.20 | 23.03±6.11 | | |
| | | F=32.527; p=0.001 | | | |

**Table 8.** Pre-test and post-test comparison of the bench press values of the groups

| Variables | N | Pre-test | Post- test | F | p |
|---|---|---|---|---|---|
| | | X̄ ± SD | X̄ ± SD | | |
| Modified German Volume Training | 11 | 0.98±0.28 | 1.28±0.26 | | |
| Super Set | 11 | 0.88±0.21 | 1.17±0.20 | 1.252 | 0.302 |
| Giant Set | 9 | 0.88±0.20 | 1.08±0.24 | | |
| Total | 31 | 0.91±0.23 | 1.28±0.24 | | |
| | | F=308.172; p=0.001 | | | |

**Table 9.** Pre-test and post-test comparison of barbell row values of the groups

| Variables | N | Pre-test | Post- test | F | p |
|---|---|---|---|---|---|
| | | X̄ ± SD | X̄ ± SD | | |
| Modified German Volume Training | 11 | 1.10±0.27 | 1.35±0.27 | | |
| Super Set | 11 | 1.04±0.18 | 1.30±0.17 | 0.744 | 0.485 |
| Giant Set | 9 | 1.03±0.26 | 1.15±0.31 | | |
| Total | 31 | 1.06±0.23 | 1.28±0.26 | | |
| | | F=241.897; p=0.001 | | | |

**Table 10.** Pre-test and post-test comparison of shoulder press values of the groups

| Variables | N | Pre-test | Post- test | F | p |
|---|---|---|---|---|---|
| | | $\bar{X}$ ± SD | $\bar{X}$ ± SD | | |
| Modified German Volume Training | 11 | 0.99±0.23 | 1.32±0.31 | | |
| Super Set | 11 | 0.71±0.32 | 1.07±0.30 | 4.517 | 0.020 |
| Giant Set | 9 | 0.72±0.24 | 0.90±0.26 | | |
| Total | 31 | 0.81±0.29 | 1.11±0.33 | | |
| | | F=193.293; p=0.001 | | | |

according to the groups (p>0.05). Also, it was revealed that the group*time interaction was statistically significant (F=9.390; p=0.001). Accordingly, it was determined that the increase in barbell row values in the GS group was less than the increase in the barbell row values of the other groups.

When examined the Table 10, it was determined that the averages of the pre-test and post-test shoulder press values showed a statistical difference (p<0.05). Accordingly, it was determined that the shoulder press values increased between the pre-test and the post-test. In addition, it was determined that the shoulder press values differed statistically according to the groups (p<0.05). Accordingly, the average of the shoulder press values of the GS group is lower than the other groups. Also, the group*time interaction was statistically significant (F=6.520; p=0.005). Accordingly, it was determined that the increase in shoulder press values in the GS group was less than the increase in the shoulder press values of the other groups.

## Discussions

In the study, the effects of MGVT, SS and GS methods on maximal strength, muscle thickness and CSA were examined in a 6-week training period. The study revealed several important findings. When these results were examined, a positive increase was detected in the 1RM strength, muscle thickness and CSA values of all groups in the six-week period. Although no difference was observed between the groups, the group*time interaction was found to be statistically significant in 1RM strength values. According to these values, it was determined that the GS group increased less than the MGVT and SS groups. In the hypothesis of the study, we expected more muscle strength and hypertrophy development in the group that applied the MGVT method, but according to the results, there was no difference between the three methods. When evaluated in general, it can be said that three sets method do not have advantages or disadvantages compared to each other for muscle strength and hypertrophy gain.

When the related studies are examined, it is seen that the training experience level of the participants is one of the main factors affecting the result of the study. In studies where the training level of the participants is high, it is seen that set methods reveal more positive developments than traditional resistance training. In this context Prestes et al. [18], compared rest pause and traditional training methods in athletes with good training levels. When the results are examined, it is seen that the rest pause method produces a greater increase in muscle hypertrophy compared to the traditional method. Similarly Bjørnsen et al. [19] compared Blood Flow Restriction and traditional training method in 17 powerlifter athletes competing on the national surface. According to the results, the Blood Flow Restriction method has produced more positive results in muscle hypertrophy. On the other hand, in the participants with low training levels, improvement was observed in all groups and there was no difference between the sets methods and the traditional method. However Ozaki et al. [20] and Fink et al. [21] compared the drop set and traditional methods in untrained individuals. According to the results, improvement was observed in all groups, but no difference was found between the groups. In this direction, when studies comparing more than one set method are examined, as in our research, positive developments are observed in all set methods in studies conducted with participants whose training background is not at a good level, but it is seen that no difference can be detected between the groups. Amirthalingam et al. [2] compared MGVT and GVT methods in his study. Although improvement was observed in both groups, no difference was found between the groups. Damas et al. [22] compared high and low training frequency on 20 untrained male participants. According to the results, positive increases were observed in both groups, but no difference was found between the two groups. Fink et al. [23] compared training with heavy and light loads in his study and similarly, no difference was found between the groups. These studies are similar to our study in terms of the duration of the training period, the characteristics of the participant group and the results they reveal, and support our findings. However, another important factor affecting the results of the studies is the length of the applied training period. In this direction, Amirthalingam et al. [2] and Hackett et al. [6] are two studies

examining the MGVT method. The characteristics of the participant groups of the studies are the same, and the only difference between the two studies is the length of the training period: six weeks [2] and twelve weeks [6]. When the duration of the training period increased to twelve weeks, it was determined that there was a difference between the sets methods. At the same time, there may be many parameters that may affect the outcome of the study. Some of those; rest time between sets, training frequency, exercise order, load amount and number of sets etc. When the studies with these parameters and with trained participants were examined, improvement was observed in all groups and differences were detected between the groups [17, 24, 25, 26, 27, 28].

As a result, this study has some limitations. The first of these is that the participant group of the research does not consist of well-trained individuals. As we mentioned in the literature, it is seen that different results can occur in studies with well-trained individuals. Second, the 6-week training period may not be optimal for assessing the extent of adaptation in muscle strength, thickness, and cross-sectional area parameters. At the same time, a previous study showed that biceps and triceps CSA increased after 6 weeks of resistance training (RT), with no significant improvement after 8 and 12 weeks compared to 6 weeks [29]. The third is that the total duration of the training, the rest intervals between sets and exercises are different from each other in the three methods. Due to these limitations, there may not have been a difference between the groups. In future research, different results can be obtained by using well trained individuals, longer training periods and different rest periods between sets.

## Conclusions

The use of set methods in the development of strength and hypertrophy is an important criterion to increase efficiency. The results of this study reveal that there is no difference between the MGVT, SS and GS methods in the 1RM strength and hypertrophy development of young male individuals who do not have a history of resistance exercise but have completed the adaptation period, and that there is an improvement in all set methods. In order to better understand the effects of these set methods, studies with different sample groups, training periods and different technical applications are necessary.

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## Conflict of İnterest

The authors declare no conflict of interest.

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PHYSICAL EDUCATION OF STUDENTS

ORIGINAL ARTICLE

# Comparison of physical performance profiles in freestyle and Greco-Roman wrestlers

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Authors' Contribution: A – Study design; B – Data collection; C – Statistical analysis; D – Manuscript Preparation; E – Funds Collection

**Abstract**

*Background and Study Aim*: This study aimed to examine the differences between a range of performance parameters in Greco-Roman and freestyle wrestlers.

*Material and Methods*: The study group consisted of 60 young wrestlers, of which 30 were Greco-Roman, and 30 were freestyle. The parameters analysed in the study included aerobic endurance, lower and upper extremity anaerobic power and capacity, postural sway, change of direction, sprint (5m-10m-20m-30m), and visual reaction. After calculating mean and standard deviation values with descriptive statistical methods, the conformity of all variables to normal distribution was checked with the Shapiro-Wilk Test. Differences between freestyle and Greco-Roman wrestlers were determined by t-test for independent samples. A discriminant function analysis was also utilized to discover which set of factors best distinguished freestyle and Greco-Roman wrestlers. The homogeneity matrices were tested for equality of covariance using Box's M test. Data collinearity was investigated in order to find correlations between independent variables. The statistical significance level was accepted as $p<0.05$.

*Results*: Aerobic endurance, lower and upper extremity anaerobic power and capacity, postural sway (Right Foot Anterior-Posterior, Left Foot Total, Left Anterior-Posterior, Left Foot Medial-Lateral), change of direction, 5m and 10m sprint values, and visual reaction values of Greco-Roman and Freestyle wrestlers were found similar ($p>0.05$). In contrast, a significant difference ($p<0.05$) was seen in 20m and 30m sprints, double foot total, anterior-posterior, medial-lateral, right foot total, and right foot medial-lateral postural sway values.

*Conclusions*: Contrary to expectations, it was seen that the leg anaerobic power values of Greco-Roman athletes and the arm anaerobic values of freestyle wrestlers were higher than other style wrestlers, with minor difference. Greco-Roman and freestyle wrestlers can be said to show similar performance values despite the different wrestling techniques and training methods they use.

**Keywords**: wrestling, physical performance, postural sway, anaerobic power, visual reaction, sprint

## Introduction

Dating back to ancient Olympics, wrestling has become an inseparable part of national and international sports organizations, standing out as an important combat sport whose popularity has been ever-increasing from the 1896 modern Olympics to the present. Historically, wrestling first emerged in the Greek (Greco) society, followed by the Romans. Both societies made wrestling a part of their social lives, and subsequently, also of the athletic games they organized [1]. In the course of time, wrestling became more effective and gained popularity all over the world, taking on the name Greco-Roman wrestling as a tribute to the two societies it had emerged from [1, 2].

There are two styles of wrestling officially recognized by the Olympic Committee. Greco-Roman is known as the classical style and it forbids any holds below the waist [3, 4]. Freestyle, on the other hand, is considered as an alternative style that allows holds involving both the upper and lower body, meaning that the whole body can be used. [3, 4]. Wrestling is a sport discipline characterised by high-intensity combat with a total of 6 minutes (2 x 3 minutes) of competition in both styles. Therefore, wrestlers undergo frequent and intense training in order to attain a high-level physical profile [5, 6].

The primary aim of wrestling is to gain superiority over the opponent by using technical, tactical and psychological factors as well as physical performance [7]. Wrestlers have to compete with more than one opponent in a day in wrestling matches [8, 9, 10]. The way to success in elite level wrestling sport requires superior physical and physiological abilities.

The anaerobic ATP-CP (adenosine triphosphate-creatine phosphate) and anaerobic glycolytic systems, as well as the aerobic system, are utilised


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in both Greco-Roman and freestyle [11]. Wrestlers are required to have a strong anaerobic energy metabolism in order to perform high-intensity attacks and counterattacks that necessitate strength, muscular power, and isometric force [5, 12].

The lower and upper body's anaerobic strength is also critical for wrestling success, as it aids in attacking and lifting the opponent during offensive techniques, as well as resisting the opponent's strikes. Anaerobic power is another criterion that could help to draw a distinction between successful and unsuccessful wrestlers.

Wrestlers must also have strong aerobic capacity since they undertake acts that require all-out bursts of maximum power with only a few seconds of recovery time [11, 13]. During the match, top-level wrestlers do approximately 16 high-intensity actions lasting 3.1 seconds each, with a 23.6-second variable-intensity recovery time [14]. To succeed in competition, wrestlers must possess numerous unique qualities, including maximal strength, aerobic endurance, and anaerobic skills [15].

The capacity to lift the opponent during attack and resist strikes when on defence demonstrates the importance of lower and upper body force [3, 16]. High maximal power production in arm and leg muscles has been a characteristic of elite wrestlers [17], since there is a direct relationship between optimal performance and strength in wrestling [18].

Pulling and pushing repeatedly, controlling takedowns, and maintaining or resisting the arch posture all necessitate strength and core and postural stability in wrestling. Wrestlers' defensive power increases when they maintain postural stability and body control in difficult circumstances [19].

Different techniques applied in Greco-Roman and freestyle wrestling show that different performance parameters come to the fore in displaying maximum performance in both styles [3, 10, 20], and the training methods to be applied to the wrestlers of both styles should be planned accordingly.

*Purpose of the Study*. The study purpose was to determine the performance differences that will help trainers and conditioners to prepare scientific-based training programs and optimize training interventions in order to achieve high performance in freestyle and Greco-Roman wrestling.

## Materials and Methods

*Participants*

A total of 60 wrestlers (30 freestyle and 30 Greco-Roman style) participated in this study, each being a member of a wrestling training centre in Turkey and a medallist in national and international competitions. The study complied with the Declaration of Helsinki and was approved by the Bioethics Commission of the University of Yalova in Turkey (Protocol No: 2022/03). The physical characteristics and training experience of the Freestyle and Greco-Roman wrestlers are presented in Table 1.

*Study Design*

This study was designed to compare the performance parameters of Greco-Roman and freestyle wrestlers. Wrestlers at Turkey wrestling training centres participated in this study voluntarily. The tests conducted under this study included aerobic endurance, anaerobic power, sprint, agility, visual reaction tests and postural sway analysis. The participants' parents read and signed an informed consent form before the participants were enrolled to the study. The athletes were not allowed to participate in daily training programs in the 24 hours preceding testing. On six different days, all of the wrestlers were tested in the same laboratory and outdoor facilities. The participants and their coaches were informed about the experimental procedures as well as the project's potential hazards and

**Table 1.** Descriptive characteristics of Freestyle and Greco-Roman wrestlers.

| Parameters | Greco-Roman | Freestyle | t | p |
|---|---|---|---|---|
| Age (years) | 19.90 ± 0.29 | 18.49 ± 0.32 | 2.983 | 0.004 |
| Height (cm) | 171.76 ± 6.80 | 165.46 ±8.07 | 3.268 | 0.002 |
| Body mass (kg) | 70.83 ±12.55 | 65.33 ±15.33 | 1.520 | 0.134 |
| Fat % | 9.4 ±5.6 | 8.2±6.3 | 1.215 | 0.048 |
| FFM (kg) | 66.7±11.23 | 53.3 ±13.30 | 1.849 | 0.005 |
| BMI ($kg/m^2$) | 23.94 ±3.55 | 23.61 ±3.76 | 0.337 | 0.737 |
| Training experience (years) | 6.06 ±1.48 | 5.8 ±1.93 | 0.599 | 0.552 |
| $VO_{2max}$ ($ml.kg^{-1}.min^{-1}$) | 53.74 ±3.76 | 53.45 ±4.30 | 0.341 | 0.733 |

Subject characteristics were measured mean ± SD; FFM - Fat Free Mass; BMI - Body Mass Index; p>0.05

advantages. The participants were given the option to conduct the tests at submaximal intensity after a familiarization session at the start of the study. All of the participants' measurements were taken on six different days in total. The tests were conducted between 9:00 a.m. and 11:00 a.m. Throughout the trial, all participants followed the same diet plan as devised by their dietician. Subjects were verbally encouraged to maximize their performance in the tests (Figure 1).

| | |
|---|---|
| Day 1 | Familiarization |
| Day 2 | Measurement of physical characteristics and $VO_{2max}$ Test |
| Day 3 | Wingate Leg Test |
| Day 4 | Visual Reaction Test |
| | Wingate Arm Crank Test |
| Day 5 | Sway Analysis Test |
| | Sprint Test |
| Day 6 | Change of Direction Test |
| A rest period of 48 hours was applied between testing days. | |
| On days with 2 tests, the tests were performed one in the morning and one in the afternoon. | |

**Figure 1.** Study Design

*Physical Characteristics*

Body mass (BM), body fat percentage (Fat %), and fat free mass FFM (kg) were measured using the bioelectrical impedance analysis method (BIA) (MC 980, Tanita Corp.,1000 kHz, Japan) after 12 hours of fasting.

*Maximum Oxygen Consumption Test*

The participants' $VO_{2max}$ values were determined using a Yo-Yo intermittent recovery test (level 1). This test comprised 20-meter shuttle runs at increasing speeds, followed by 10 seconds of active recovery (consisting of 2x5-meter jogging) until fatigue. The test began at a speed of 10 $kmh^{-1}$ and increased till exhaustion [21].

Audio beeps from a smartphone application regulated the speed. The test was terminated when the participants failed to cross the finish line in time twice, and the covered distance was recorded as the valid score, which was then employed in the calculation below [22]:

$$VO_{2max}\ (ml.kg^{-1}.min^{-1}) = \text{distance (m)} \times 0.0084 + 36.4$$

*Anaerobic Power and Capacity Tests*

On different days, the participants conducted 30-second Wingate anaerobic tests on an adjustable Monark cycle ergometer (Model 894-E, Stockholm, Sweden) to evaluate anaerobic power and capacity. For each participant, the Wingate leg test consisted of maximal cycling in a standing body position against a resistance load of 75 $g.kg^{-1}$ BM, while the Wingate arm crank test consisted of maximal cycling in a standing body posture against a resistance load of 55 $g.kg^{-1}$ BM. The cycle set was calibrated according to manufacturer's instructions before each test. The individuals warmed up by pedalling at 60–70 rpm for 5 minutes, followed by 3 all-out sprints in the last 5 seconds of the last 3 minutes. The individuals were then given a 5-minute passive rest time. The cadence speed was monitored in real time simultaneously during the tests (the participants could see through the monitor). The peak power (PP) in watts for any 5-second period was computed, as was the mean power (MP) for the 30 seconds. In addition, BM-related relative values were determined.

*Sprint test*

The participants performed a sprint test that consisted of two maximal 30 m sprints with timing at 5m, 10m, 20m, and 30 m, with a 3 minute rest time between each sprint, after a standardized 15-minute warm-up (low-intensity running, multiple acceleration runs, and stretching activities).

*Pro-agility Test*

Pins were set 5 yards (4,57m) to the left and right of the pro-agility test, often known as 20 yard running test. At the starting line, a timing gate (Microgate, Bolzano, Italy) was installed. Repeated passes were documented in this manner. Wrestlers took their positions before the test began. Once ready to start, the wrestlers were instructed to touch the pins alternatingly, starting with the pin to the right and then the one to the left, then cross the starting line and complete the test. The total time for each participant was recorded.

*Postural sway analysis*

The centre-of-pressure data was collected using a Kistler 9281C force platform (400 x 600 mm) based on piezoelectrical measurement of ground-reaction force in the anteroposterior (AP), mediolateral (ML), and vertical planes. Participants stood with their feet together and arms at their sides, barefoot. Postural sway was measured under three different position feedback conditions, namely double leg, right leg, and left leg. During sway analysis, participants were asked to fix their attention on a stationary object positioned 2 meters in front of them at eye level. Wrestlers were put through familiarization tests, and each trial (double and singles leg) lasted 30 seconds, followed by a one-minute rest period. The experiments were conducted in random order. Total average sway, AP, and ML directions were determined using 30-second centre of pressure (COP) data.

*Reaction time*

The Witty SEM diagnostic system was used to assess reaction time to eight visual stimuli. Microgate Witty SEM is a technology that consists of "intelligent traffic lights", which are made up of a matrix of multicoloured 7x5 Light Emitting Diode (LED) that can manage various symbols and colours. Eight light photocells were set on a board across

from the wrestlers. The aim was to use a dominant hand to react as quickly as possible to photocells that lit up blue. Other photocells displayed a variety of colours or none at all. This experiment included 60 visual reactions with a producing time of one second. Total time was calculated from the better of two tries.

*Statistical Analysis*

SPSS version 21.0 software was used for statistical analysis, and a p value of 0.05 was considered significant. Normality of data was controlled using the Shapiro-Wilk test. The data was examined with descriptive statistics, and the findings were reported as mean standard deviation. An independent t-test was used to examine the differences between young freestyle and Greco-Roman wrestlers. Additionally, the effect size (0.2: small, 0.5: medium, and 0.8: big) was evaluated to determine practical significance [23]. A discriminant function analysis was also utilized to discover which set of factors best distinguished freestyle and Greco-Roman wrestlers. The homogeneity matrices were tested for equality of covariance using Box's M test. Data collinearity was investigated in order to find correlations between independent variables. The discriminant function analysis model removed variables that were highly linked (r > 0.70) with each other. The characteristics that distinguished freestyle and Greco-Roman wrestlers were determined using the structural coefficient. For the interpretation of linear vectors, a structural coefficient greater than 0.30 was considered significant.

## Results

The characteristics and training experiences of Greco-Roman and Freestyle wrestlers are presented in Table 1. Age, height, Body Fat % and FFM values of Greco-Roman and Freestyle wrestlers differed significantly ($p<0.05$), yet without any significant difference in terms of body mass, BMI, training experiences and $VO_{2max}$ values ($p>0.05$).

According to arm and leg anaerobic power and capacity test results, there was a statistically significant difference between Leg PD values of freestyle and Greco-Roman wrestlers ($p<0.05$). However, no significant difference was seen in both leg and arm PP, RAP, AP and RAP values between the groups ($p>0.05$) (Table 2).

According to postural sway test results, there was a statistically significant difference in all sway directions in double leg and right leg ($p<0.05$). But there was no significant difference between the groups in all left leg sway directions ($p>0.05$) (Table 3).

Agility, 5m, 10m and visual reaction of Greco-Roman and Freestyle wrestlers were similar ($p>0.05$). When the 20m and 30m sprint values are examined, it is seen that Greco-Roman wrestlers are faster than Freestyle wrestlers ($p<0.05$) (Table 4).

The administered power, sprint, visual reaction, agility, and postural sway tests classified the freestyle and Greco-Roman wrestlers correctly by 66,7% (Table 5).

## Discussion

In this study, we examined the differences between the performance parameters of Greco-Roman and freestyle wrestlers. The results of the study showed that, while the height (cm), fat% and FFM (kg) of Greco-Roman and freestyle wrestlers displayed similar characteristics, there was a significant difference in body weight (kg), training experience (years) and $VO_{2max}$ characteristics (Table 1). Although there was no significant difference between the Peak Power (PP), Relative Peak Power (RPP), Average Power (AP), Relative Average Power

**Table 2.** Comparison of leg and arm anaerobic power and capacity.

| **Leg** | **Greco-Roman** | **Freestyle** | **t** | **p** | **ES** |
|---|---|---|---|---|---|
| Peak Power (W) | 922.6 ±167.14 | 844.77 ±210.50 | 1.586 | .118 | 0.40 |
| Relative Peak Power (W/kg) | 13.25 ±2.08 | 12.96 ±1.46 | .608 | .545 | 0.16 |
| Average Power (W) | 621.63 ±102.80 | 577.75 ±139.05 | 1.390 | .170 | 0.35 |
| Relative Average Power (W/kg) | 8.86 ±0.62 | 8.84 ±0.69 | .078 | .938 | 0.03 |
| Power Drop (%) | 63.64 ±10.50 | 57.82 ±6.94 | 2.535 | .014 | 0.65 |
| **Arm** | **Greco-Roman** | **Freestyle** | **t** | **p** | **ES** |
| Peak Power (W) | 800.78 ±188.29 | 771.04 ±185.24 | .617 | .540 | 0.15 |
| Relative Peak Power (W/kg) | 11.33 ±1.80 | 11.93 ±2.12 | -1.177 | .244 | 0.30 |
| Average Power (W) | 424.17 ±82.52 | 395.29 ±89.60 | 1.298 | .199 | 0.33 |
| Relative Average Power (W/kg) | 6.00 ±0.52 | 6.08 ±0.59 | -.552 | .583 | 0.14 |
| Power Drop (%) | 81.06 ±10.84 | 80.79 ±10.81 | .094 | .925 | 0.02 |

ES - effect size

**Table 3.** Comparison of postural sway.

| Sway Analysis (Eyes Open) | Greco-Roman | Freestyle | t | p | ES |
|---|---|---|---|---|---|
| Double Leg Total (mm) | 315.4 ±79.66 | 372.90 ±102.34 | -2.428 | 0.02 | 0.62 |
| Double Leg Anterior-Posterior(mm) | 230.5 ±60.92 | 263.16 ±64.78 | -2.012 | 0.05 | 0.52 |
| Double Leg Medial-Lateral(mm) | 165.36 ±52.66 | 206.73 ±75.86 | -2.453 | 0.02 | 0.64 |
| Right Foot Total (mm) | 1366.33 ±272.49 | 1551.06 ±437.47 | -1.963 | 0.05 | 0.51 |
| Right Foot Anterior-Posterior(mm) | 865.13 ±183.95 | 975.66 ±345.49 | -1.547 | 0.03 | 0.39 |
| Right Foot Medial-Lateral(mm) | 879.43 ±187.65 | 1002.73 ±236.09 | -2.239 | 0.03 | 0.57 |
| Left Foot Total (mm) | 1350.40 ±348.21 | 1465.03 ±566.88 | -.944 | 0.35 | 0.24 |
| Left Foot Anterior-Posterior(mm) | 876.20 ±278.30 | 920.40 ±445.68 | -.461 | 0.65 | 0.11 |
| Left Foot Medial-Lateral(mm) | 853.90 ±186.12 | 945.50 ±279.89 | -1.493 | 0.14 | 0.38 |

EB - energy balance

**Table 4.** Comparison of agility, speed, and reaction.

| Agility (s) | Greco-Roman | Freestyle | t | p | ES |
|---|---|---|---|---|---|
| Pro-Right Side | 2.65 ±0.15 | 2.65 ±0.11 | .067 | .947 | 0 |
| Pro-Left Side | 2.46 ±0.12 | 2.49 ±0.13 | -.893 | .375 | 0.23 |
| Pro-Total | 5.11 ±0.23 | 5.13 ±0.19 | -.337 | .737 | 0.09 |
| Sprint (s) | Greco-Roman | Freestyle | t | p | EB |
| 5m | 1.06 ±0.08 | 1.09 ±0.09 | -1.292 | .201 | 0.35 |
| 10m | 1.83 ±0.07 | 1.86 ±0.09 | -1.265 | .211 | 0.37 |
| 20m | 3.16 ±0.10 | 3.23 ±0.16 | -2.136 | .037 | 0.52 |
| 30m | 4.42 ±0.14 | 4.57 ±0.126 | -2.812 | .007 | 1.15 |
| **Reaction** | **Greco-Roman** | **Freestyle** | **t** | **p** | **ES** |
| Visual | 48.73 ±4.5 | 49.50 ±5.6 | -.586 | .560 | 0.15 |

ES - effect size

**Table 5.** Classification of groups according to the discriminant function[a]

| Original group | n of cases | Predicted group membership | |
|---|---|---|---|
| | | Greco-Roman | Freestyle |
| Greco-Roman | 30 | %70 (21) | %63,3 (19) |
| Freestyle | 30 | %36,7 (11) | %30,7 (9) |

a. 66,7% of original grouped cases correctly classified.

(RAP) values of leg and arm anaerobic power and capacities between the groups, it was observed that the anaerobic power capacity values of Greco-Roman wrestlers were higher than those of Freestyle wrestlers, which shows that there is a significant difference between leg Power Drop (PD %) values for both groups (Table 2).

When the literature is examined, it can be seen that the number of studies examining the differences in anaerobic power and capacity between wrestling styles is limited. Demirkıran et al. examined the differences between certain physical fitness parameters of young Greco-Roman and freestyle wrestlers [3]. They found that, while lower extremity anaerobic power and capacity values (except RAP) were similar, arm anaerobic power and capacities were higher in Greco-Roman style wrestlers. The authors attributed this difference between the two styles to the fact that Greco-Roman wrestlers perform dynamic movements (i.e. lifting, throwing, and resisting the opponent) both during training and in competition, and that all techniques in the Greco-Roman style involve the upper body.

In contrast, in a study by Kılınç and Özen the

authors compared the anaerobic power values of elite freestyle and Greco-Roman wrestlers, no significant difference could be found between the absolute and relative anaerobic values of the leg and arm in both styles [24].

Similarly, Lopez-Gullon et al. did not find any significant differences in arm anaerobic power and capacity (absolute or RPP and AP) results [25], which results support the findings of our study. The results of studies examining wrestlers at different competitive levels showed that elite male wrestlers had higher leg and arm PP and MP values compared to amateur wrestlers [15, 18, 26]. The authors attributed this difference to higher lean body mass and greater neural activation in elite wrestlers.

Garcia Pellares et al. (2012) compared female wrestlers according to different levels of competition (elite-amateur) and weights (light-middle). Their study revealed that amateur wrestlers had lower upper extremity MP and PP values compared to elite wrestlers (17.3-23%) [7]. Against this background, anaerobic power and capacity level seem to be critical indicators of achieving high-level success in wrestling [5]. Studies comparing the weights of wrestlers showed that heavier wrestlers had higher absolute arm and leg PP and MP values in both genders [11, 15, 18, 25, 27, 28].

In study aimed at determining the hierarchy of success factors in wrestling regardless of style and weight class, Cieśliński et al. found that the peak strength of upper extremity muscles was at the top of the success factors in wrestling [29]. As a result, previous studies have reported that anaerobic power and capacity are important variables to accurately distinguish between successful and unsuccessful athletes, regardless of wrestling style, age category and weight [5]. However, due to the different results between studies, further studies should be conducted in the future.

To the best of our knowledge, no study was conducted yet to compare the postural sway values of Greco-Roman and Freestyle wrestlers. In this study, freestyle wrestlers were found to have higher postural sway values than Greco-Roman style wrestlers. However, this difference was not statistically significant. One of the reasons why freestyle wrestlers have higher postural sway values may be because they have less muscle mass and less leg anaerobic power. Furthermore, the hamstrings of freestyle wrestlers are more extensible than those of Greco-Roman wrestlers because freestyle wrestlers do more flexibility exercises during training, whereas Greco-Roman wrestlers do more lateral trunk bending than freestyle wrestlers.

Few researchers in the literature have examined the reaction times of wrestlers [29, 30, 31]. In our study, no significant difference was found between the visual reaction times of Greco-Roman and freestyle wrestlers ($p>0.05$).

In the study examining the reaction times of Greco-Roman and freestyle wrestlers, Mirzaei et al. reported that there was no difference between the reaction times between the groups , which result is similar to that of our study [31]. Gierczuk et al. examined the changes in reaction times of Greco-Roman wrestlers and the relationship between their reaction times and their technical and tactical actions during a match, as a result of which they found that elite wrestlers showed a smaller improvement in reaction time and performed more technical and tactical moves during a match. There are studies where the ability to react quickly at sub-maximal intensity is reported to be an important factor in determining the outcome of competition [32].

Cieśliński et al. reported that the response time to light signal was an important success factor in wrestling [29], because during a match, wrestlers need to properly record, process and counter the different moves of their opponents. Therefore, reaction time in wrestling is of particular importance and should not be ignored in determining performance.

The sprint and change of direction values of Greco-Roman and Freestyle wrestlers in our study are given in Table 4. There was no significant difference between 5m, 10m, visual reaction and agility values in both groups ($p>0.05$). However, there was a significant difference between the 20m and 30m sprint values in both groups ($p<0.05$).

Baic et al. did not find a significant difference between the 20m sprint values of Greco-Roman and freestyle wrestlers [33]. Lopez-Gullon et al. determined that there was no difference between the 10m sprint values of the Greco-Roman and freestyle wrestlers according to weight [25]. Mirzaei et al. showed in their study that the 40 yard sprint values of Greco-Roman and freestyle wrestlers were similar [31]. Demirkıran et al. found in their study a significant difference between the 10 m and 30 m sprint and agility values of Greco-Roman and freestyle wrestlers [3].

## Conclusions

Contrary to expectations, it was seen that the leg anaerobic power values of Greco-Roman athletes and the arm anaerobic values of freestyle wrestlers were higher than other style wrestlers, with minor difference. Styles showing similarity in agility and acceleration speed parameters were superior to Greco-Roman style wrestlers in terms of postural sway, visual reaction, and speed values. This finding can be associated with the balance and speed superiority of Greco-Roman wrestlers, especially in leg anaerobic power. As a result, Greco-Roman wrestlers can be said to give greater importance to strength and strength-enhancing parameters, while the methods of workout in different wrestling styles have influence on anaerobic power, balance, and reaction characteristics.

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PHYSICAL EDUCATION OF STUDENTS

ORIGINAL ARTICLE

# Investigation of different training methods integrated into soccer training on body composition and athletic performance

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Authors' Contribution: A – Study design; B – Data collection; C – Statistical analysis; D – Manuscript Preparation; E – Funds Collection

**Abstract**

*Background and Study Aim* The aim of the study is to investigate the effects of 8-week core and plyometric training on body composition and athletic performance in young male soccer players.

*Material and Methods* 24 young male soccer players participated in the study voluntarily. The subjects were randomly divided into three separate groups: Core training group (CTG), plyometric training group (PTG) and control group (CG). In addition to soccer training two days a week for 8 weeks, the training was applied to the subjects according to the training programs determined. Physical measurements (Height, Body Weight, Body Mass Index, Fat Mass, Lean Mass) and performance measurements (Vertical Jump, Horizontal Jump, Plyometric Jump, 20 m speed, Agility) were made 8 weeks before and after the study. Subject's measurements were analyzed in the SPSS 22 program.

*Results* The largest percentage and significant difference in agility, speed, vertical jump and plyometric jump parameters was obtained in PTG, while the largest percentage and significant difference in horizontal jump parameters was obtained in CTG. While no difference was found in speed and agility performance in CTG; there are significant differences in jump performance but these differences are lower than the other experimental groups in terms of percentage difference. On the other hand in body composition, a significant change was observed only in the height parameter in PTG.

*Conclusions* If a faster improvement is desired in the determined athletic performance parameters in a period of eight weeks in soccer, it may be recommended to prefer core and plyometric trainings in addition to branch training.

**Keywords**: soccer, core, plyometrics, body composition, athletic performance

## Introduction

Being successful in sports is possible today with scientific methods. In order to achieve success in sports, it is aimed to increase the performance of the athlete physically and psychologically with long-term training programming [1]. There are many factors that affect performance in sports. One of the factors affecting the high performance expected from the athlete is the physical structure of the athlete, and this combines with other performance elements such as strength, power, flexibility, speed, endurance and quickness, giving a positive or negative direction to the performance of the athlete [2]. The physical, physiological and psychological characteristics required for the sportive performances expected from high-level athletes have always been among the subjects of interest. For this purpose, extensive and comprehensive studies have been carried out in the literature in order to define the characteristic structures of athletes interested in different sports branches [3, 4, 5]. Soccer is undoubtedly one of the sports research topics that the performances of the athletes are the most curious and focused on. Soccer is a sport that includes high and low intensity movement processes in an aerobic environment in terms of game time. Unlike many other sports in soccer, during a 90-minute soccer match, soccer players perform many explosive movements such as kicking, fighting, jumping, turning, sprinting and changing speed [6]. These movements consist of different technical and tactical skills. With this feature, it is a sport that has physical and physiological competencies that affect performance such as high-level aerobic and anaerobic endurance, strength, flexibility, speed, quickness, balance, reaction. In soccer, coaches want players to be able to perform high-intensity movements in the game in the best way in every part of long playing time. In addition, soccer players must have a strong muscle structure in order to perform better than their opponents and to prevent possible injuries. At this point, core and plyometric training can be counted among the methods most frequently used by trainers. The core region of the body consists of passive and active structures such as muscles, connective tissues (ligaments, tendons), bones that form and surround the pelvis and spinal canal [7]. The greater the core strength of the athlete, the


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greater the power generation in the arms and legs [8]. Core training includes exercises to train the muscles that control and stabilize abdominal, waist and hip movements. Core strength and stabilization play an important role in efficiently transmitting the power generated during an activity from the trunk to the extremities or from the extremities to the trunk. [9]. Therefore, core training will provide some benefits not only for the development of some physiological and motoric features of footballers considering their upper level training and success but also for time and money [10]. Core training is generally preferred to improve an individual's balance, strength, anatomical function, and flexibility [11]. Unlike many other branches, soccer is a sport where many movements must be performed quickly and without planning. As it is known, the magnitude of the explosive force directly affects the jump performance. [12]. Jumping performance is an important part of sportive performance, although it has different importance in sports branches. Soccer is one of these sports branches. Plyometric training includes exercises in which active muscles are stretched before shortening. Plyometric exercise is a type of exercise used to increase the muscle's ability to generate power. Plyometric exercise increases the flexibility of the muscles by using activities such as jumping, jumping and limiting. Plyometric training has been shown to increase jumping ability and power of other explosive movements [13]. In the light of these data, it was aimed to investigate the effects of 8-week core and plyometric training on body composition and athletic performance in young male soccer players.

## Materials and Methods

*Participants*

24 male soccer players aged 17-18 participated in the study voluntarily. This study, which was carried out according to the ethical standards of the Declaration of Helsinki. Approved by the Health Sciences Ethics Committee of Bingöl University.

*Research Design*

Before the study, the subjects participating in the study were told the necessary details about the research method, and consent forms were filled and signed by the participants and their parents. Those with previous lumbar and lower extremity injuries, cardiovascular disease, and any condition that could affect the exercise process and results were excluded from the study. The subjects were randomly divided into three separate groups: Core Training Group (CTG, n=8), Plyometric Training Group (PTG, n=8), Control Group (CG, n=8). All groups participated in the same soccer training three days a week for eight weeks, while the first group performed eight-week core and the second group eight-week plyometric training programs (Table 1, Table 2). The third group participated in this study as a control group

**Table 1.** Core training program

| Movement Name | First 4 weeks | | Second 4 weeks | |
|---|---|---|---|---|
| | Repetition | Sets | Repetition | Sets |
| Plank, sec | 15 | 4 | 15 | 6 |
| Side plank right, sec | 15 | 2 | 15 | 4 |
| Side plank left, sec | 15 | 2 | 15 | 4 |
| Crunch on pilates ball, reps | 15 | 1 | 15 | 2 |
| Back extension on pilates ball, reps | 15 | 1 | 15 | 2 |
| Russian twist, reps | 15 | 2 | 15 | 4 |
| Hip raise, reps | 15 | 1 | 15 | 2 |
| Dog kick right and left, reps | 15 | 1 | 15 | 2 |

**Table 2.** Plyometric training program

| Movement Name | First 4 weeks | | Second 4 weeks | |
|---|---|---|---|---|
| | Repetition, pieces | Sets | Repetition, pieces | Sets |
| Horizontal jump | 6 | 2 | 8 | 2 |
| Vertical jump | 6 | 2 | 8 | 2 |
| Horizontal jump sideways (right) | 6 | 1 | 8 | 1 |
| Horizontal jump sideways (left) | 6 | 1 | 8 | 1 |
| Lateral bounding | 10 | 2 | 12 | 2 |
| Forward leap over a 30 cm obstacle | 6 | 2 | 8 | 2 |
| Side jump over 30 cm obstacle (right) | 6 | 1 | 8 | 1 |
| Side jump over 30 cm obstacle (left) | 6 | 1 | 8 | 1 |

did just soccer training. Inclusion criteria was determined as being a male soccer player between the ages of 17-18 whose sports age (SA) was at least two years, not having any injury or surgery and not participating any plyometric and core training in the last six months, not being involved in any sports branch other than football training and not miss any practice during the measurement and tests. In the body fat ratio measurements of the subjects; body mass index (BMI), body fat percentage (BFP), lean mass (LM), fat mass (FM), body composition analysis data were obtained. In order to determine athletic performance; 20 m sprint test, Illinois agility test, and within the scope of jump tests, vertical jump (VJ) test, horizontal jump (HJ) test, plyometric jump (PJ) test measurements were applied to the athletes.

*Anthropometric Measurements*

*Height and Body Weight (BW) Measurement:* Height was measured to the nearest 0.1 cm using a fixed stadiometer (Holtain, UK) and BW was measured to the nearest 0.1 kg with a standard scale (Medisana, Germany) using a portable balance [14].

*Determination of Body Composition:* Tanita BC-418 MA body composition analyzer was used.

*Performance Measurements*

*20 m Sprint Test:* 20 meter test was used to measure the speed skills of subjects. The subjects started the test 1 meter behind from the starting line and the acceleration and speed values were recorded with the photocells placed 20 meters (Newtest 2000; Newtest Oy, Oulu, Finland).

*Illinois Agility Test:* The agility performance of the subjects was determined by the Illinois agility test. The starting photocell began test duration when athlete passed starting point of the test. All athletes tried to complete test track as soon as possible. Test duration was automatically recorded with an accuracy of 0.01 seconds by photocell system (Newtest 2000; Newtest Oy, Oulu, Finland) when athlete passed end point of the test. The Illinois test was performed two times with three minutes rest intervals [15].

*Vertical Jump Test:* The subject stood beside a wall, started from a static standing position, reached up as high as possible with one hand and marks the wall with his fingertips. The jump was preceded by flexing the knees to approximately 90°; the subject jumped up with maximum effort as fast as he could and made a sign on the wall again with the same hand. The difference between these two marks in centimetres was considered as the maximum vertical jump height [16]. Three attempts were made and the best result was recorded.

*Horizontal Jump Test:* The starting position required subjects to stand with their feet shoulder-width a part behind a starting line and their arms loosely hanging down. On the command ready, set, go, participants executed a countermovement with their legs and arms and jumped at maximal effort in the horizontal direction. Participants had to land with both feet at the same time and were not allowed to fall forward or backward. The horizontal distance between the starting line and the heel of the rear foot was recorded via tape measure to the nearest 1 cm [17]. Soccer players jumped 3 times and the highest score was recorded.

*Plyometric Jump Test:* In this test, players change places after a kick-off line, taking three steps on the horizontal axis and jumping the furthest. Subjects' hands are on the waist during this test. The subjects moved directly forward without taking a step after the starting line. He lands on the ground with first right, then left, then double steps, and the distance from the starting line to the last place he reached was recorded in cm. Three measurements were taken from the subjects with appropriate rest intervals for this test and the best score was recorded as the test value.

*Statistical Analysis*

The analysis of the data was evaluated in the SPSS 22 package program. Arithmetic means, within-group mean and standard deviation values have been determined. Comparisons between groups were made with the Paired-Samples T Test. The significance level was determined as $p<0.05$.

## Results

Age, sports age, height and BW data for all groups are shown in the Table 3.

**Table 3.** Characteristics of the subjects.

| Variables | Core Training Group (n=8) | Plyometric Training Group (n=8) | Control Group (n=8) |
|---|---|---|---|
| Age (years) | 17.2±0.4 | 17.3±0.5 | 17.7±0.5 |
| Sports Age (years) | 3.5±1.1 | 3.5±0.8 | 3.2±0.8 |
| Height (cm) | 175.0±7.8 | 175.8±5.1 | 179.7±9.8 |
| Body Weight (kg) | 76.4±12.4 | 61.4±4.3 | 70.7±12.1 |

After eight weeks of core training, no significant difference was found in the body composition values of the subjects in CTG. After eight weeks of plyometric training, changes in height, fat percentage and FM in PTG were determined to be significantly different. A significant increase was found only in the LM parameter in CG who only did soccer training (Table 4, $p<0.05$).

After eight weeks of core and plyometric training in young male soccer players, in the VJ performance in the groups, in the pre & post tests, respectively; Performance data were obtained with a 7% significant increase in CTG ($p<0.001$), a 13.5% significant increase in PTG ($p<0.001$), and a 3% significant increase in CG ($p<0.05$). The biggest change in VJ performance was observed in PTG (Table 5).

**Table 4.** Comparison of in-group body composition data of young male soccer players before and after core and plyometric training

| Variables | Groups | Pre-test X±Sd | Post-test X±Sd | p |
|---|---|---|---|---|
| Height (cm) | CTG | 175.0±7.8 | 175.8±8.0 | 0.500 |
| | PTG | 175.8±5.1 | 177.2±5.6 | 0.043* |
| | CG | 179.7±9.8 | 181.7±9.7 | 0.250 |
| Body Weight (kg) | CTG | 76.4±12.4 | 77.9±13.3 | 0.111 |
| | PTG | 61.4±4.3 | 62.4±5.5 | 0.207 |
| | CG | 70.7±12.1 | 69.8±10.9 | 0.404 |
| Body Mass Index (kg/m$^2$) | CTG | 25.2±5.5 | 25.9±5.4 | 0.194 |
| | PTG | 19.8±1.2 | 19.9±1.6 | 0.712 |
| | CG | 21.9±3.7 | 21.6±3.3 | 0.352 |
| Fat (%) | CTG | 18.7±6.9 | 17.3±10.3 | 0.742 |
| | PTG | 9.7±2.8 | 8.0±2.7 | 0.038* |
| | CG | 14.3±5.7 | 13.6±6.5 | 0.458 |
| Fat Mass (kg) | CTG | 15.3±8.3 | 13.4±9.8 | 0.322 |
| | PTG | 6.1±2.1 | 4.9±2.0 | 0.026* |
| | CG | 10,4±5.2 | 10.1±6.2 | 0.712 |
| Lean Mass (kg) | CTG | 62.6±6.6 | 63.0±5.2 | 0.822 |
| | PTG | 54.4±3.4 | 56.3±4.8 | 0.017* |
| | CG | 59.4±7.4 | 60.6±8.1 | 0.018* |

Note: CTG - Core Training Group, PTG - Plyometric Training Group; CG - Control Group; * - p<0.05

**Table 5.** Comparison of in-group athletic performance data of young male soccer players before and after core and plyometric training.

| Variables | Groups | Pre-test X±Sd | Post-test X±Sd | p |
|---|---|---|---|---|
| Vertical Jump (cm) | CTG | 40.3±10.8 | 43.2±10.8 | 0.001** |
| | PTG | 42.3±11.7 | 48.0±11.3 | 0.001** |
| | CG | 39.3±3.3 | 40.3±2.9 | 0.041* |
| Horizontal Jump (cm) | CTG | 186.8±48.3 | 194.2±49.9 | 0.031* |
| | PTG | 178.7±33.1 | 184.2±33.4 | 0.010* |
| | CG | 172.2±10.4 | 173.2±10.8 | 0.041* |
| Plyometric Jump (cm) | CTG | 564.2±75.3 | 571.7±75.6 | 0.031* |
| | PTG | 595.0±75.8 | 604.3±73.3 | 0.001** |
| | CG | 600.8±35.4 | 602.3±36.6 | 0.017* |
| 20 m (sec) | CTG | 3.59±0.34 | 3.49±0.39 | 0.031* |
| | PTG | 3.40±0.30 | 3.21±0.24 | 0.000** |
| | CG | 3.54±0.33 | 3.51±0.31 | 0.107 |
| Agility (sec) | CTG | 17.50±1.04 | 17.01±0.89 | 0.003** |
| | PTG | 17.55±0.71 | 16.92±0.60 | 0.009** |
| | CG | 17.69±0.71 | 17.60±0.63 | 0.063 |

**: p<0.01; *: p<0.05

After eight weeks of core and plyometric training in soccer players, in the HJ performance in the groups, in the pre & post tests, respectively; Performance data were obtained with a 4% significant increase in CTG ($p<0.05$), a 3% significant increase in PTG ($p<0.05$), and a 0.5% significant increase in CG ($p<0.05$). The biggest difference in HJ performance was observed in CTG (Table 5).

In the plyometric jump performance, in the pre & post tests respectively; Performance data were obtained with a 1.3% significant increase in CTG ($p<0.05$), a 1.6% significant increase in PTG ($p<0.01$), and a 0.2% significant increase in CG ($p<0.05$). The greatest change in PJ performance was observed in PTG in the positive direction (Table 5).

At the 20 m sprint performance, in the pre & post tests respectively; Performance data were obtained with a significant decrease of 2.9% in CTG and 5.6% in PTG ($p<0.05$), and a non-significant decrease of 0.8% in CG. In sprint performance, a significant decrease was observed in both PTG and CTG, with a higher rate in PTG (Table 5).

In the agility performance groups, in the pre & post tests respectively; Performance data were obtained with a significant decrease of 2.9% in CTG and 3.7% in PTG ($p<0.01$), and a non-significant decrease of 0.5% in CG. The biggest difference in agility performance was observed in PTG (Table 5).

## Discussion

Sadeghi et al. reported that they did not detect any difference in height value in their study in 2013 in which they examined the effects of 6-week core and plyometric training on 11-14 age group boys [18]. In another study, the effect of eight-week core training applied to soccer players on some physical and physiological parameters; In the study in which the study group reported the mean age as 21,52 years, no statistically significant difference was found between the pre-test and post-test results in the height parameter of the subjects. The reason for this was reported as the reason for the lack of significance in these parameters because the study was short-lived and the average age of the athletes consisted of individuals who completed their developmental period [19]. In the literature, it is stated that the growth process should be considered when evaluating physical performance in children and adolescents [20]. When the pre-test and post-test values were compared in the study, it was found that there was a significant increase in the height of PTG among the subjects participating in our study ($p<0.05$). It is thought that the main reason why this difference cannot be the result of the training we have done in a short period of 8 weeks can be explained by the fact that the subjects are in their growing age. Chely et al. did not reveal any significant difference in terms of the body weights of the participants in the 8-week plyometric training conducted with young handball players in the middle of the season [21]. When the body weight values of the subjects were examined in our study, no statistical difference was found as a result of the study. When we look at some studies in the literature, it is reported that plyometric training has no effect on body weight [22, 23]. According to this information, it can be said that plyometric studies have no effect on the body weight of the subjects.

After eight weeks of core training, no significant difference was found in the body composition values of the subjects in the core training group ($p>0.05$). There are not many studies that reveal the effect of core training programs on the body composition characteristics of athletes. As a result of the breakdown of high amounts of calories with training, decreases in body fat percentage ocur [24]. While strength training increases lean body weight with an anabolic effect, studies on sedentary individuals generally have positive effects on body composition, as it causes changes in body composition by decreasing body fat percentage [25; 26] but this effect is not reported in the literature in studies with athletes [27, 28, 29]. Because, considering that the athletes already have certain body composition suitability such as high lean body mass and low fat mass due to their regular training, it can be explained why core stabilization exercises do not cause body composition changes in athletes.

One of the high performance indicators in soccer is the jumping feature. The largest percentage and significant difference in VJ and PJ parameters was obtained in PTG, while the largest percentage and significant difference in HJ parameters was obtained in CTG. While there are significant differences in jump performance in CG who only practiced soccer for eight weeks, these differences are lower than the other experimental groups in terms of percentage difference. As a result of correct strength training, there should be improvement in VJ, HJ and maximal half squat values [30]. In Singh's study examining the effects of plyometric training on adolescent taekwondo players, it is reported that plyometric training significantly increases the VJ height [31]. In a meta-analysis study conducted by Markovic (2007) on plyometric studies, it was observed that plyometric training increased the VJ height and it is argued that plyometric training is an effective physical conditioning method to increase the VJ performance of healthy people [32]. Rahmat et al. reported that the 6-week core stabilization program increased the long jump performance by stopping in 17 children aged 9-12 years [33]. These studies support our study. According to these data, we can say that plyometric training has an improving effect on the jumping feature.

Speed and agility are important features that provide one step closer to the ball in soccer, especially in offensive or defensive positions that will

determine the outcome of the match. In our study, in addition to the improvement in both experimental groups, it was determined that there was more improvement in two features in PTG. In CG, there was no difference in speed and agility performance at the end of eight weeks in athletes. Günay and Yüce found a statistically significant change in the 20m sprint test values in the experimental group after the 8-week core strength training program ($p<0.05$), but did not find any significance in the control group [34]. Fernandez et al. reported that there was a positive and significant improvement in the speed feature of the experimental group in their study in which they examined the effects of 8-week plyometric training on the performance parameters of young tennis players [35]. Michael et al., in their study investigating the effect of plyometric training on agility, reported that there was a significant increase in t-test agility values in the experimental group, but no difference in the control group [36]. Sadeghi et al. reported that there was a statistically significant increase in agility in both core and plyometric training groups in their study examining the effects of 6-week core and plyometric training on 11-14 age group boys [18]. Looking at similar studies in the literature, it seems that the significant change in speed and agility values in our study overlaps with other studies. In this case, it can be said that strength training contributes positively to sprint and agility time.

## Conclusions

In this study, it was aimed to examine the effects of eight-week core and plyometric training on body composition and athletic performance in young male soccer players. After eight weeks of core training, a significant difference was determined in all athletic performance values in CTG. After eight weeks of plyometric training, a significant difference was determined in other athletic performance values, except sprint performance, in PTG. While there are minimal quantitative changes in CG who only trains soccer, this difference is not significant in speed and agility performance. However, at the end of eight weeks, a significant difference was found in jump performances in CG. This is thought to be due to regular soccer training.

As a result; If a faster improvement in the body composition and athletic performance parameters of soccer players is desired in a period of eight weeks, core and plyometric trainings are recommended in addition to branch training. When planning the training, it is important to pay attention to the number of repetitions, sets and series to be determined by considering the prerequisites such as the age of the athletes and their strength status.

## Conflict of interest

The authors declare no conflict of interest.

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PHYSICAL EDUCATION OF STUDENTS

ORIGINAL ARTICLE

# Virtual physical education: Google Meet as an alternative platform for learning skill-based concepts

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Authors' Contribution: A – Study design; B – Data collection; C – Statistical analysis; D – Manuscript Preparation; E – Funds Collection

**Abstract**

*Background and Study Aim* Google Meet has been the most highly sought videoconferencing platform utilized by various educational institutions worldwide to facilitate synchronous classes. The said videoconferencing platform is highly efficient based on previously published scholarly works. In line with this, the study aimed to explore the factors linked with students' acceptance and observation of Google Meet. It is also focused on evaluating the effectiveness of the platform vis-à-vis learning skill-based concepts by adopting the Technology Acceptance Model.

*Material and Methods* The selected respondents were composed of 2nd-4th year undergraduate students taking Bachelor of Physical Education at City College of Angeles (Angeles, Philippines). The respondents for the study were identified by using the purposive sampling technique. From the 467 entire populaces, 250 students answered the online survey, and all responses were accepted after data cleaning. The Partial Least Squares-Structural Equation Modeling or PLS-SEM through SmartPLS4 was used to explore the factors affecting students' acceptance of Google Classroom (as an alternative platform to learning skill-based concepts in various Physical Education courses). Additionally, outer loadings and the average variance extracted (AVE) were scrutinized and the Fornell-Larcker criterion, cross-loadings, and Heterotrait-Monotrait Ratio (HTMT) were assessed to establish convergent and discriminant validity. Also, a full collinearity assessment on the outer model was performed to determine if the model is free from Common Method Bias (CMB). Meanwhile, PLS Predict was utilized to determine the model's predicting validity and power. Lastly, the structural model was evaluated through path coefficients and the coefficient of determination (R2).

*Results* After obtaining data from the samples (N=250) of Bachelor of Physical Education students (Female= 42.0% and Male= 58.0%) utilizing Partial Least Square-Structural Equation Modeling through SmartPLS4, the results displayed that: perceived ease of use is positively and significantly associated with and triggers perceived usefulness; perceived ease of use and perceived usefulness are significantly linked with and leverages students' behavioral intention to use; and, behavioral intention to use is positively interrelated with and affects the actual use of the videoconferencing platform.

*Conclusions* The results postulated that PEOU and PU are corroborated to influence BI ensuing the AU of Google Meet. The findings of this study will be used by the Physical Education Department and the college administration to assess if the platform may continuously be used for all skill-based courses. This is in line with the current setting of the investigation since the college is still in a full-online learning modality. Proposals concerning the students, teachers, and future research directions are also presented.

**Keywords**: acceptance, e-learning, google meet, physical education, skill-based concepts, technology acceptance model, videoconferencing platform

## GLOSSARY

Construct's Items.

*Perceived usefulness of Google Meet in skill-based concepts in Physical Education (PEOU):*

PEOU1- Google meet enhances my efficiency;
PEOU2- Google Meet enhances my learning productivity;
PEOU3- Google Meet enables me to accomplish tasks more quickly;
PEOU4- Google Meet improves my performance;
PEOU5- Google Meet saves my time;
PEOU6- Google Meet doesn't have any distinctive useful features;
PEOU7- Google Meet is not applicable to all skill-based concepts in Physical Education.

*Perceived ease of use of Google Meet (PU):*

PU1- Google Meet is easy to use;
PU2- Google Meet enables me to access course materials in skill-based courses in Physical Education;
PU3- Google Meet is convenient and user-friendly;
PU4- Google Meet allows me to submit/present my assignments/quizzes through video and live presentation;
PU5- Google Meet requires no training;
PU6- Google Meet makes it easier to avoid academic difficulties in learning skill-based concepts in Physical Education.

Behavioral Intention to use Google Meet (BI):

BI1- I intend to increase my use of the Google Meet;
BI2- It is worth to recommend Google Meet to other students;
BI3- I'm interested to use the Google Classroom more


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frequently in the future.
*Actual System Use (AU):*
AU1- I use the Google Meet on daily basis;
AU2- I use the Google Meet frequently.

## Introduction

The online learning modality provided numerous advantages and benefits during the onslaught of COVID-19, where all schools were forced to close temporarily due to the rampant spread of the virus [1]. From the traditional face-to-face, all classes were forced to shift to a virtual learning environment [2]. The modality, as mentioned earlier, has been utilized by various educational institutions globally to facilitate students' erudition in the comfort of everyone's home. Even during this post-pandemic epoch, this learning modality will still play a critical role in supporting Higher Education Institutions (HEIs) to deliver quality education to students [3]. Some advantages of online learning are flexibility, easy access, and interaction between students and instructors [4]. For the instructors to meet their respective classes and facilitate class synchronously, institutions have been utilizing various videoconferencing suites, including Google Meet (formerly known as Hangout Meet), which is currently integrated with Google Classroom. Introduced by Google Apps for Education (GAFE) in 2014, Google Classroom is a learning management system (LMS) and also a virtual classroom that allows teachers to create and organize educational materials and assignments quicker, provides effective feedback on time, and communicate with learners with ease [5]. This LMS is highly designed to save time and is flexible, accessible, and incredibly mobile-friendly [6]. Undeniably, Google Meet has been used as a videoconferencing solution by most educational institutions and has been able to establish its effectiveness as a pedagogical tool for various disciplines, which was supported by numerous published scholarly works [7, 8, 9, 10]. Lamentably, there were only a few published scholarly works that were conducted in the Higher Education Institutions' context, particularly in the Local Colleges and Universities (LCUs) in the Philippines. Therefore, investigating the students' acceptance and effectiveness of Google Meet is highly needed. With the need to conduct research, this study is focused on exploring the factors that could affect students' acceptance and perception of Google Classroom as an alternative tool for teaching skill-based concepts in Physical Education. Furthermore, due to ongoing infrastructure development, the study's milieu is temporarily in a full-online learning modality. Hence, students and teachers are not permitted to conduct face-to-face classes on campus. As a final point, the findings of this study aimed to provide valuable information to physical education teachers and college administrators concerning the effectiveness of Google Meet. The results will be considered if the video conferencing application can continuously serve as an alternative platform for students to learn skill-based concepts in Physical Education.

Numerous investigations were conducted during the COVID-19 pandemic concerning e-learning, and the number of published scholarly works on the effectiveness of Google Meet as a videoconferencing application is still insufficient, especially on its efficacy as an alternative tool for learning skill-based concepts in Physical Education in the local colleges and universities setting. Scholarly works relating to Google Meet are vast to other countries and educational institutions over the recent years, on the assault of the COVID-19 virus, up until the post-pandemic period [11, 12,13]. Additionally, there have been few recent studies that have been able to utilize the Unified Theory of Acceptance and Use of Technology (UTAUT) and the Expanded Theory of Acceptance and Use of Technology (UTAUT2) providing valuable information to various HEIs the identified factors that affect students' acceptance and perception of Google Meet and its implementation to various disciplines globally [14, 15, 16]. Aside from these, there have also been studies that added other critical factors that predict students' utilization of a system [17, 18]. As mentioned above, these scholarly works were able to provide important information to help schools address the needs and demands to facilitate a quality learning experience.

As mentioned earlier, e-learning will still play a significant role in various higher educational institutions in providing quality education for students, even during this post-pandemic period. The use of Google Meet is still relative, as other HEIs worldwide still implement a full-online learning modality, which is the same in the current setting of this investigation. HEIs across the globe utilize Google Meet because of its availability and flexibility and can help students to achieve academic feats. As an example, [19] findings revealed that students and even teachers from the Department of English Language at Oran University, Algeria have an overall positive perception and attitude toward Google Meet during the assault of the COVID-19 virus. The qualitative study by [20] also reported that Google Meet could be an effective tool for elementary students from Elementary School 1 Telukagung Indramayu, Indonesia. Likewise, using Google Meet in the speaking class of students from STKIP Setia Budhi Rangkasbitung indicated a positive result, especially in their perception of its advantages rather than disadvantages [11]. Lastly, assisting lecture methods through the use of Google Meet was found to significantly influence the building knowledge and learning outcomes of elementary school teacher education at the University of Trunojoyo

Madura [21]. However, digital expertise, learners' motivation, and internet facilities were enumerated as challenges in implementing online learning using the said videoconferencing application. On a positive note, and based on the abovementioned evidence, it can be construed that Google Meet is indeed an effective pedagogical tool that can foster learning. However, numerous challenges that pose serious threats are still evident in implementing online learning through the support of Google Meet, which needs to be addressed and taken seriously. These challenges are predominantly evident based on earlier studies, in which most educational institutions constantly strive to provide quality education to students [22, 23].

Furthermore, facilitating online classes for skill-based courses in Physical Education has been a challenge faced by various educational institutions worldwide. Such as the monotony of classes within a limited environment and education content, which does not convey the value of Physical Education [1, 24]. Because of trial-and-error, this resulted in a lack of experience and expertise in the operation of Physical Education classes and limited assessment guidelines, which has made the systematic evaluation with e-learning impossible, added by Jeong and So. Moreover, online Physical Education classes were reported ineffective in improving students' motor skill acquisition and physical activity level regardless of what e-learning being utilized [25]. Lack of practical training, learning motivation and interest, and interpersonal interactions were the primary reasons of the ineffectiveness of online Physical Education class. Because of this, students are highly dissatisfied with the online discussions, conversing, interacting, participating, and speaking online [26]. Additionally, Physical Education teachers have reported difficulties because no visual connection is established [27] during online classes which resulted to unmotivated and passive student. Likewise, student-teacher interaction (i.e., feedback), technology-related experience (i.e., use of technology and unstable connection), online classroom experiences (i.e., scarcity of educational facilities, learning space and access to materials), pedagogical-related experiences (i.e., the amount of time performing physical activities, true 'value' of physical education, and lack of teacher's demonstration), and personal-related experience (i.e., learning style) were enumerated as challenges faced by students currently in an online Physical Education class reported by the findings of [28]. Physical Education's practical and social nature cannot be translated in a virtual scenario regardless of the newest discoveries and innovations [29, 30]. The shreds of evidence mentioned above have identified the different challenges that schools face in Physical Education in a virtual setting because of the discipline's nature. On the positive side, there are still noteworthy evidence reported during and after the pandemic in online Physical Education globally. Such as the findings of [31] reported that independence and adaptation to the new normal are the results of having classes in an online setting in Physical Education. Additionally, health and physical education online classes had a more favorable perception from the students concerning their experiences because of teachers' feedback and responsiveness, understanding related to the content, and health gains [32, 33]. To put it briefly, addressing these challenges experienced by students is highly obligatory to provide meaningful experiences in learning skill-based concepts in Physical Education, even in an online learning modality.

*Technology Acceptance Model (TAM) by Davis (1989)*

Several theories and models in relation to Information Systems (IS) and Intention-Based were already introduced throughout the years concerning individuals' acceptance of a new technology [34]. The most acclaimed and highly influential model is the Technology Acceptance Model (TAM) established by [35]. Based on the model of Davis, TAM posited that there are two primary exogenous factors that influence individuals' intention to use a new technology which are: Perceived ease of use (PEOU) and Perceived usefulness (PU) [36]. Perceived ease of use is the degree to which a person believes utilizing a system would not need any such efforts [37]. On the other side, perceived usefulness of a system is related to the productivity and effectiveness of the platform and its overall benefits to increase user's performance [38]. Based from previously published scholarly works, the adaptation of this specific model has been widespread across various disciplines, particularly in education, industries, and even using TAM with other exogenous variables [39, 40, 41, 42, 43]. Additionally, research papers concerning the adaptation of TAM in assessing students' acceptance and perception of various pedagogical platforms, including Google Meet, have established PEOU and PU as primary external factors that influence their behavioral intention (BI) and actual use (AU) [44, 45, 46]. Over the past years, TAM provided a solid background of its effectiveness in assessing the acceptance of new technology to individuals. To emphasize, this present study is concentrated on adopting TAM (without other exogenous variables), exploring the factors that influence students' acceptance of Google Meet as an alternative platform for learning skill-based concepts in Physical Education courses. Ergo, this study is interested to test the following hypotheses:

**$H_1$:** Perceived ease of use positively influences the perceived usefulness of Google Meet in learning skill-based concepts in Physical Education.

**H2:** Perceived ease of use positively influences

students' behavioral intention to use Google Meet in learning skill-based concepts in Physical Education.

**$H_3$:** Perceived usefulness positively influences students' behavioral intention to use Google Meet in learning skill-based concepts in Physical Education.

**$H_4$:** Behavioral intention of students influences the actual use of Google Meet in learning skill-based concepts in Physical Education.

Based from the hypotheses, the conceptual framework was formulated which is illustrated in Figure 1.

## Materials and Methods

*Participants*

The selected respondents for the study were composed of 2nd-4th year students taking Bachelor of Physical Education degree at City College of Angeles, located in the City of Angeles, Philippines. All of the participating respondents are all enrolled for the 1st Semester, the Academic Year 2022-2023. 1st-year students were not included because they are relatively new in the college. The respondents for this study were identified by using the *Purposive sampling technique*. It is a non-probability procedure where the investigator purposively chooses the respondents for the study due to the qualities they possess [47, 48]. Additionally, *Raosoft Sample Size Calculator* was used to determine the recommended sample size based on the total population. From the 467 entire populaces, the suggested sample size is 212. Exceptionally, there are 250 students who answered the online survey, and all responses were accepted after data cleaning. Based on the findings, most of the respondents are females (N=145) constituting 58.0% of the overall total sample compared to males (N=105) with 42.0% which is shown in Table 1.

**Table 1.** Gender

| Item | Values | f | Percentage |
|---|---|---|---|
| Gender | | | |
| | Female | 145 | 58.0 |
| | Male | 105 | 42.0 |

*Ethical considerations.*

All participating respondents were informed regarding the study's objectives, the questionnaire to be used, and the constructs that will be measured. The benefits of the study on the college and the scientific community were also provided. In this, the respondents were required to provide their consent by clicking the agreement attached in the Google Forms sent to them electronically. They were also given the freedom of choice whether to participate in the study or decline, which means that their participation in the survey was voluntary. Minor risks were reiterated, such as being uncomfortable in answering personal and sensitive survey questions. Likewise, no monetary compensation would be provided for giving out information. Given these circumstances, respondents are free to withdraw or to ask for a debriefing about the study anytime.

*Research Design*

*Instrument.* The tool that was used for this study is divided into two (2) sections. The first part is focused on gathering the gender of the respondents, and the second part collected all the data using the original Technology Acceptance Model by [35] which has four (4) constructs: *Perceived ease of use* [PEOU] (e.g., "Google Meet enhances my learning productivity."), *Perceived usefulness* [PU] (e.g., "Google Meet makes it easier to avoid academic difficulties in learning skill-based concepts in Physical education."), *Behavioral intention to use* [BI] (e.g., "I'm interested to use the Google Classroom more frequently in the future."), and *Actual use* [AU] (e.g., "I use the Google Meet frequently".). All items for each construct were adapted with some few adjustments to tailor-fit the instrument to the scope of this investigation. Responses are recorded in a 7-point Likert scale (1- "extremely disagree" to 7- "extremely agree"). The items that were used are shown in Glossary.

*Statistical Analysis*

The *Partial Least Squares-Structural Equation Modeling* or PLS-SEM through SmartPLS4 was used to explore the factors affecting students' acceptance of Google Classroom as an alternative platform to learning skill-based concepts in various Physical Education courses. PLS-SEM as a statistical treatment for obtained data is highly suitable for this investigation [49]. Regarding the measurement


**Figure 1.** Conceptual Framework based on Technology Acceptance Model (TAM)

model, the *outer loadings* of each item and the *average variance extracted* (AVE) were scrutinized to establish convergent validity [50]. Likewise, the *Fornell-Larcker criterion*, *cross loadings*, and *Heterotrait-Monotrait ratio* (HTMT) were assessed to establish discriminant validity [50]. Also, a full collinearity assessment on the outer model was performed to determine if the model is free from Common Method Bias or CMB [50, 51]. *PLS Predict* was utilized to determine the model's predicting validity and power [52, 53]. Finally, the structural model was evaluated through path coefficients and the coefficient of determination ($R^2$) [50, 54].

## Results

*Factor Analysis*

In order to measure the reliability of each item, a factor loading analysis was performed. A threshold value ≥0.70 for each item's loading [50]. After extracting all the items below 0.70 and removed from the model, all retained items are reliable based on the threshold value. Additionally, Cronbach's Alpha value (CA) and composite reliability should be >=0.70. The Average Variance Extracted (AVE) is used to validate constructs [55]. It is also defined as the grand mean value of the squared loadings of the items related to the construct and the standard measure for establishing convergent validity. The AVE should be >=0.50, and the corresponding p-value must be at most 0.50 [47,50]. As can be seen in Table 2, Cronbach's Alpha value, composite reliability, and average variance extracted all met the threshold value: Perceived ease of use [PEOU] (CA 0.858; CR 0.859; AVE 0.706), perceived usefulness [PU] (CA 0.830; CR 0.838; AVE 0.664), behavioral intention to use [BI] (CA 0.869; CR 0.872; AVE 0.793), and actual use [AU] (CA 0.856; CR 0.858; AVE 0.874). Hence, convergent validity has been established. On the other hand, to establish the discriminant validity, the Fornell-Larcker criterion, cross-loadings, and the Heterotrait-Monotrait Ratio should be inspected. For the Fornell-Larcker criterion, the square root of AVE (diagonal value) in each variable should surpass the correlation of latent variables as presented in Table 3. For the cross-loadings, the loading of each indicator should be higher than the loadings of its corresponding variables' indicators, as shown in Table 4. Table 5 forecasts the result of the Heterotrait-Monotrait ratio (HTMT). The HTMT value should be <0.90. Based on the findings, most of the values are <0.90. Hence, discriminant validity has been established.

Table 6 illustrates the result from the full collinearity assessment performed to determine if

**Table 2.** Measurement model results

| Constructs | Items | Loadings | CA | CR | AVE |
|---|---|---|---|---|---|
| Perceived ease of use | PEOU2 | 0.875 | 0.858 | 0.859 | 0.706 |
| | PEOU3 | 0.880 | | | |
| | PEOU4 | 0.882 | | | |
| | PEOU5 | 0.713 | | | |
| Perceived usefulness | PU2 | 0.827 | 0.830 | 0.838 | 0.664 |
| | PU3 | 0.788 | | | |
| | PU4 | 0.887 | | | |
| | PU5 | 0.750 | | | |
| Behavioral intention to use | BI1 | 0.849 | 0.869 | 0.872 | 0.793 |
| | BI2 | 0.915 | | | |
| | BI3 | 0.907 | | | |
| Actual use | AU1 | 0.939 | 0.856 | 0.858 | 0.874 |
| | AU2 | 0.931 | | | |

Item loadings >0.70, Cronbach's Alpha Value (CA) and Composite Reliability (CR) >0.70, Average Variance Extracted (AVE) >0.50 [47,50,55]such as the average variance extracted (AVE.

**Table 3.** Fornell-Larcker Critertion

| Constructs | AU | BI | PEOU | PU |
|---|---|---|---|---|
| **AU** | **0.935** | | | |
| **BI** | 0.686 | **0.891** | | |
| **PEOU** | 0.514 | 0.651 | **0.841** | |
| **PU** | 0.674 | 0.765 | 0.651 | **0.815** |

**Table 4.** Cross loading results

| Items | AU | BI | PEOU | PU |
|---|---|---|---|---|
| **AU1** | **0.939** | 0.661 | 0.504 | 0.640 |
| **AU2** | **0.931** | 0.621 | 0.455 | 0.620 |
| **BI1** | 0.594 | **0.849** | 0.566 | 0.645 |
| **BI2** | 0.651 | **0.915** | 0.595 | 0.723 |
| **BI3** | 0.586 | **0.907** | 0.576 | 0.672 |
| **PEOU2** | 0.428 | 0.571 | **0.875** | 0.546 |
| **PEOU3** | 0.414 | 0.513 | **0.880** | 0.556 |
| **PEOU4** | 0.475 | 0.565 | **0.882** | 0.536 |
| **PEOU5** | 0.405 | 0.531 | **0.713** | 0.544 |
| **PU2** | 0.561 | 0.607 | 0.518 | **0.827** |
| **PU3** | 0.508 | 0.605 | 0.593 | **0.788** |
| **PU4** | 0.611 | 0.706 | 0.562 | **0.887** |
| **PU5** | 0.514 | 0.565 | 0.437 | **0.750** |

**Table 5.** Heterotrait-Monotrait Ratio (HTMT)

| Constructs | AU | BI | PEOU | PU |
|---|---|---|---|---|
| **AU** | | | | |
| **BI** | 0.794 | | | |
| **PEOU** | 0.599 | 0.754 | | |
| **PU** | 0.800 | 0.897 | 0.768 | |

Heterotrait-Monotrait ratio (HTMT) <0.90 [56]

**Table 6.** Collinearity Statistics (VIF) – Outer model

| Items | VIF |
|---|---|
| AU1 | 2.270 |
| AU2 | 2.270 |
| BI1 | 1.850 |
| BI2 | 2.858 |
| BI3 | 2.827 |
| PEOU2 | 2.825 |
| PEOU3 | 2.615 |
| PEOU4 | 2.845 |
| PEOU5 | 1.381 |
| PU2 | 2.172 |
| PU3 | 1.632 |
| PU4 | 2.619 |
| PU5 | 1.533 |

VIF Values should be <3.3 threshold [50, 51].

the model is free from common method bias (CMB). In this, VIF values should be <3.3 threshold [50, 51]. Based on the findings, all items have VIF values <3.3. Hence, the result can be interpreted that the model is unrestricted from CMB.

Table 7 illustrates the results after performing PLSPredict assessing the predictive power/validity of the model. Additionally, $Q^2$ predict values should be >0 as can be seen on the table. Furthermore, after investigating the PLS-SEM MV error histogram, most of the indicators are symmetrical. Hence, PLS-SEM_RMSE and LM_RMSE can be compared to determine the predictive power of the model. Based on the findings, that majority of indicators in PLS-SEM_RMSE are lower than LM_RMSE, and this can be interpreted that the model has a moderate

predictive power. The result is in accordance to the guidelines as set by [53].

*Structural Model Assessment*

The explanatory power of the model has been evaluated by measuring the discrepancy amount in the dependent variables of the model. As [50] have stated, the R2 and the path coefficients are the essential measures for assessing the structural model. As seen in Figure 2, the model has R2 value of PU is 42.1%, BI 62.2%, and AU 46.9% respectively.

The model was bootstrapped into 10,000 subsamples for the path analysis, as suggested by scholars [50, 57, 58]. Each hypothesis' path coefficient and p-values are illustrated in Figure 2 and Table 8. Based on the findings, students' perceived ease of use (PEOU) is positively linked with and triggers their perceived usefulness (PU) of Google Meet, which supported H1 ($\beta$ = 0.651, p <.05). Also, students' perceived ease of use (PEOU) and perceived usefulness (PU) are significantly interconnected with and influences their behavioral intention (BI) to use the said videoconferencing platform which indicates that H2 ($\beta$ = 0.266, p <.05) and H3 ($\beta$ = 0.592, p <.05) were supported. Finally, students' behavioral intention to use (BI) is associated with and impacts their actual use (AU)

**Table 7.** Model's Predictive power using PLSPredict

| Items | $Q^2$ Predict | PLS-SEM_RMSE | PLS-SEM_MAE | LM_RMSE | LM_MAE |
|---|---|---|---|---|---|
| AU1 | 0.234 | 1.050 | 0.836 | 1.067 | 0.840 |
| AU2 | 0.194 | 1.080 | 0.850 | 1.093 | 0.859 |
| BI1 | 0.307 | 0.974 | 0.724 | 0.991 | 0.733 |
| BI2 | 0.338 | 0.999 | 0.749 | 1.011 | 0.757 |
| BI3 | 0.318 | 1.066 | 0.801 | 1.073 | 0.809 |
| PU2 | 0.247 | 0.981 | 0.718 | 0.973 | 0.710 |
| PU3 | 0.337 | 1.113 | 0.822 | 1.125 | 0.805 |
| PU4 | 0.298 | 0.954 | 0.727 | 0.944 | 0.723 |
| PU5 | 0.176 | 1.151 | 0.848 | 1.171 | 0.866 |

If all the indicators in the PLS-SEM analysis have lower RMSE (or MAE) value compared to the naïve LM benchmark, the model has high predictive power; if the majority (or the same number) of indicators in the PLS-SEM analysis yields smaller prediction errors compared to the LM, this indicates a medium predictive power; if a minority of the dependent construct's indicators produce lower PLS-SEM prediction errors compared to the naïve LM benchmark, this indicates the model has low predictive power; and if the PLS-SEM analysis (compared to the LM) yields lower prediction errors in terms of the RMSE (or the MAE) for none of the indicators, this indicates the model lacks predictive power [52].

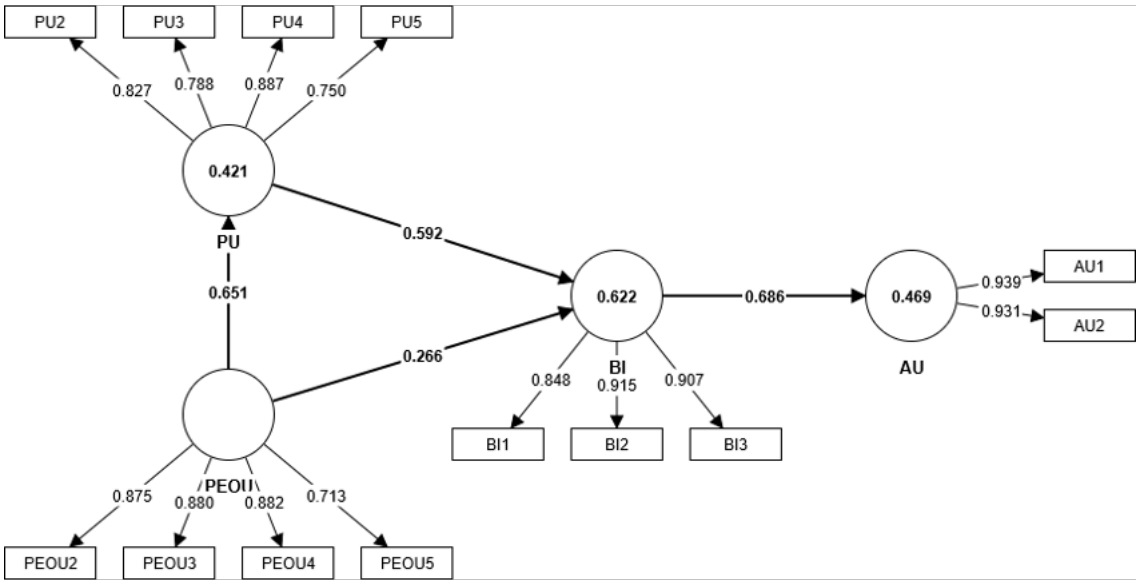


**Figure 2.** Path analysis results

**Table 8.** Hypotheses testing results

| Hypotheses | Path | Path Coefficient | *p-value* | Decision |
|---|---|---|---|---|
| $H_1$ | PEOU → PU | 0.651 | 0.000 | Supported |
| $H_2$ | PEOU → BI | 0.266 | 0.000 | Supported |
| $H_3$ | PU → BI | 0.592 | 0.000 | Supported |
| $H_4$ | BI → AU | 0.686 | 0.000 | Supported |

of Google Meet as an alternative platform to learn skill-based concepts in Physical Education, which can be posited that H4 has been supported ($\beta$ = 0.686, p <.05).

## Discussion

Findings discovered that PEOU and PU are indeed external factors that are positively associated with and trigger students' behavioral intention and the use of Google Meet as an alternative pedagogical platform in learning skill-based concepts in various Physical Education courses. Ergo, the findings posited that the utilization of the said videoconferencing platform is undeniably effortless and easy to operate, which echoed the findings of previously conducted investigations [8, 59]. Also, students' positive perception of Google Meet as an effective platform can enhance class performance due to its accessibility and practicality. The findings are parallel to the study of [60] which indicated that using Google Meet as a videoconferencing tool to facilitate online classes could increase students' academic performance, and improve motivation [11, 19]. On the one hand, this present study has only focused on the direct effect of PEOU and PU as exogenous factors on the BI and AU of Bachelor of Physical Education students toward Google Meet. It is constrained to the factors mentioned in the Technology Acceptance Model (TAM) with no other additional exogenous variables/factors. As mentioned earlier, other factors could also affect BI and AU, which are not mentioned in this present investigation. For a more in-depth explanation, social and performance expectancy were also factors that can directly affect BI and AU based on the Unified Theory of Acceptance and Use of Technology (UTAUT) [15, 61], while facilitating conditions, hedonic motivations, and event habits were also revealed as external factors based on previously conducted studies adopting the Extended Unified Theory of Acceptance and Use of Technology (UTAUT2) [62, 63]. Published scholarly works supporting this study's findings are based on various disciplines from various educational institutions. The results of this investigation are significant because it has demonstrated an important task: to provide new knowledge and data that can fill the gap between research across the field of educational technology and physical education. Most importantly, the findings benefit City College of Angeles, especially for all the Physical Education teachers and the college administrators, as it provided a picture of the effectiveness of Google Meet as an alternative platform for students to learn skill-based concepts in Physical Education. Additionally, these findings will determine whether the department will continue using the said platform or the other way around. This is in line with the commitment of the college to provide quality education to students even in a full-online learning modality.

## Conclusions

Adopting the Technology Acceptance Model (TAM) and after performing partial least square-structural equation modeling (PLS-SEM), it has been verified that perceived ease of use (PEOU) and perceived usefulness (PU) can significantly affect Bachelor of Physical Education students' behavioral intention and actual use of Google Meet as an alternative tool in learning skill-based concepts in Physical Education. The critical features significantly affecting students' perception of operating the platform are its familiarity and effortlessness. Interestingly, another remarkable finding was that Bachelor of Physical Education students could rely on Google Meet as an alternative platform to efficiently learn and acquire skill-based concepts while leveraging the college's educational system. The conclusions have been derived based on students' high reliance on the platform as per previously cited constructs. With this, Google Meet's benefits may be maximized by providing various training opportunities for the Bachelor of Physical Education students. The practical features of the videoconferencing platform should be comprehensively explored so that no students will be left behind, especially during this time of fast-evolving technological discoveries.

From a professional development perspective, providing in-depth and extensive training to Physical Education instructors to explore and maximize the operation of Google Classroom through Google Meet will significantly help their respective online classes. Additionally, additional training focusing on creative pedagogical techniques applicable in an online learning modality is highly suggested to improve creativity that may catch the interest and boost the motivation of students taking Physical Education courses, which may result in exceptional

academic feats. The proposals mentioned above are based on previously conducted studies reporting teachers' inadequate knowledge of operating and facilitating teaching and learning in an online learning modality. Therefore, policymakers and practitioners should provide interventions to address these challenges faced by Physical Education instructors and to increase their familiarity with the platform, which may greatly support and help their professional careers. It is only imperative to provide such activities for instructors, as they facilitate the teaching and learning process. Also, it is well known that teachers' capacity and knowledge operating the platform may affect students' interest, motivation, and engagement in class.

Above all, the limitations of this study are fundamental to note. First, this study is limited as it only adopted the Technology Acceptance Model (TAM) without other exogenous variables, as mentioned in the discussion. It was also emphasized that aside from the perceived ease of use (PEOU) and perceived usefulness (PU), other exogenic factors were identified that affect students' behavioral intention (BI) and actual use (AU) of a pedagogical platform. Therefore, adopting the Unified Theory of Acceptance and Use of Technology (UTAUT), Extended Unified Theory of Acceptance and Use of Technology (UTAUT2), or other behavior-intention theories and models for future research is highly proposed to determine these factors' influence on students' behavioral intention and actual use of Google Meet in learning skill-based concepts in Physical Education. Additionally, a qualitative or mixed-method design is highly recommended as it will provide a more profound and in-depth discovery of the various factors that could affect students' acceptance and usage of the said videoconferencing platform. Aside from these, the present investigation is restricted to students taking the Bachelor of Education program at City College of Angeles. Hence, the result of this study may not be able to generalize the entire students of Higher Education Institutions (HEIs) in the city or even in the country. In this regard, future scholars may find curiosity in conducting a similar inquiry by collecting data from other private and public higher education institutions to determine if the findings may be supported or opposed. Finally, a multi-informant approach or design for future research may be applied by collecting Physical Education teachers' reports, as they can provide more profound information regarding their perception and acceptance of Google Meet as an alternative pedagogical tool for teaching skill-based concepts for various courses in Physical Education.

To end, this study contributes to the body of knowledge and the existing literature, filling the gap between research concerning the effectiveness of Google Meet in learning skill-based concepts in Physical Education based on students' acceptance and perception of the said videoconferencing platform, especially in local colleges and universities milieu due to scarcity of published scholarly works concerning this present investigation.

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## Conflict of interest

The author declares no conflict of interest.

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PHYSICAL EDUCATION OF STUDENTS

ORIGINAL ARTICLE

# The effect of using the two competitive teaching styles and stations on learning some basic football skills for physical education students

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**Abstract**

*Background and Study Aim*: The present study investigates the effect of two different teaching methods, which are represented in the collective competitive method and the station method in teaching some basic football skills to students of faculty of physical education and sports sciences at the university of Benghazi, which can be used by workers in the field of teaching physical education.

*Material and Methods*: Data were collected with 40 students. The research sample was divided randomly into two groups of (20) students for each group, where the first group applied the competitive method, and the second applied the stations method. A quantitative study used based on tests and measurements consisting to identifying basic skills in football.

*Results*: Students shared several two experimental groups approach. However, significant differences emerged in developing some basic football skills. The competitive method made a remarkable development in all basic skills. However, the latest stations style marked development in all basic skills. In addition, data are provided indicating that the competitive style surpassed the stations method in the post tests in all basic skills.

*Conclusions*: The physical education lesson is important area to improve the motor performances and acquisition of the basic skills. In this context, students largely support the practice of the ball. This study will encourage teachers to use two styles (competitive style and station style) to develop the basic skills of football, organize the units in such a way that they achieve the principle of continuity through succession between the parts of the skill to teach.

**Keywords**: physical education, teaching practice, football skills, competitive method.

## Introduction

Football is a collective sport of confrontation, intention and tactical game decision. However, professional performance is based on harmonious management [1]. Brady et al. [2] describe the world of football as a "talent economy". Senaux [3] underlines that the professional player has an individual talent conditioned by the perfect complementarity of the players. Also, it is a motor activity that values the collective mastery of a balance of power between two teams after numerous duels, in order to win. In other words, it is an art of combining and optimizing the actions of players to achieve victory [4]. In this context, the technical side is more important in training even if the physical side remains a priority [5]. In this sense, Turpin [4] defines training as a process that produces a modification (physical, motor, cognitive, affective). From this, Mercier [6] specifies everything that includes physical, technical-tactical, intellectual and moral preparation with the help of physical exercises. Currently, football is the most popular social form of physical practice, both in terms of the number of practitioners and in terms of media coverage [7]. It represents "a cultural phenomenon whose echoes can be heard well beyond the stadiums" [8].

Indeed, children do not do physical education (EP) at school but sports. More specifically, teachers are encouraged to draw on physical, sporting and artistic practices present in society. Thus, the competitive sports model (assuming codified confrontation) is the main mode of practice offered to students [9]. In other words, as proposed by [10], the practice of football in EP can constitute "an opportunity for students to build themselves through the presence of others. Thus, the teaching of team sports at school must reflect the balance of power, and its structures, by systematizing situations that bring into play the reality of the opposition specific to team sports [11]. The teaching of football at school can be summed up in the application of the tactical model insofar as it allows the transmission of principles of the game, roles to be understood and recreated in the situation and actions which change or move the game [11]. In this context, the physical education lesson, in its concept and units, makes a contribution to the student's life, and is an important area of public education in


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society, a vital part of modern education, it is main axis of the educational process directed towards the pupil, it helps to improve the motor performances of the pupils and their acquisition of the basic skills. It helps the learner to gain experience through exercises, competitions and games with colleagues or alone [12, 13]. Gréhaigne et al. [14] note that the student will quickly have to be confronted with making complex strategic and tactical choices (diversity of alternatives, combination of actions) and with significant time pressure, which seems to be expected by the students. This is why the tactics and the strategy cannot be eluded by the teachers for the elaboration of a cycle of football. Especially since this approach will allow students to adapt to changes in status (defender / attacker) but also to anticipate and sequence actions despite the opposition. Hebert [7] opined that the EP teachers generally show less affection than students for the sport. This observation is confirmed in the school context since teachers rank football in last position among their favorite physical activities. This is not the case for students who largely support the practice of the ball in physical education.

Therefore, it seems that the diversity of teaching methods and models have generated increased interest among teachers [7, 15, 16]. Some authors suggest that teachers look for different methods to teach effectively and achieve educational purposes [17, 18]. Through the program and the objectives set, it is knowing how the student learns but it is also important to know what he has learned [19, 20, 21]. Resulting from the reflections of several researchers, a teacher cannot rely solely on his academic knowledge; he/she must also have additional training providing him with didactic and pedagogical skills [22, 23]. As a result, the activity of PE teachers is apprehended in situations which aim to mobilize and maintain the work collective that constitutes the students [24, 25].

This research is related to cognitive development in the field of human sciences in general, physical education in particular, and teaching methods and methods. Indeed, studies in the field of physical education envisage a better future for achieving educational purposes and benefiting from the evolution of teaching methods in the light of scientific development [26]. Remarkably, teaching football using the traditional method depends on the experience of the teacher and the program. In this study, we tried two new teaching methods (the competitive method and the station method) in learning basic soccer skills. At the faculty of physical education and sports sciences at the university of Benghazi, what is the effect of using the competitive teaching method on learning some basic football skills for students of the first experimental group? What is the effect of using the method of teaching stations on learning some basic skills in football for students of the second experimental group? Are there statistically significant differences in measurements dimensional between the first and the second experimental group in developing some basic football skills?

## Material and Methods

*Participants*

The research involved a cohort of 40 students (STs) males (76,92 %), from total 52 STs (100 %) studying in the faculty of physical education and sports sciences at the university of Benghazi. Two female students and 10 students were excluded from the research community and outside the research sample. All participants in this study were volunteers'. They were recruited from a single faculty of physical education and sports (Libye). The group of participants consisted of the third year. The ages of the participants varied from 21 to 25 years old and the mean age was 21.42 (*SD* = 0.63). All were aged between (23 ± 2 years) registered in the first year, by the master's degree in physical education. The research sample was divided randomly into two groups of 20 students for each group, where the first group applied the competitive method, and the second applied the stations method (see Table 1).

*Research Design*

In this study, we chose the experimental approach to ensure internal and external validity of the results. In order to achieve the objective, this approach was used with two equivalent groups.

Regarding the variables related to the research, we formed equal groups and performed a parity between them to adjust the variables (1) age measured by year, (2) weight measured in kilograms, (3) height measured in centimeters. The significance of the differences in the above variables is approved. Also, equivalence was determined between members

**Table 1.** The research sample for the two experimental groups

| Variable | Total number | Group | Experimental |
|---|---|---|---|
| Competitive method | 20 | First | Experimental (1) |
| The style of the stations | 20 | Second | Experimental (2) |
| | 40 | | Total |

of the two research groups. The tabular (t) value at the significance level (0.05) and degree of freedom (18) is (2.10). The results show that there are no significant differences in variables, indicating the homogeneity of the two sample groups (see Table 3).

Equality was also conducted between members of the two sample groups in basic football skills. This is to identify the level of the students in these skills, and to check the parity of the two groups. The tabular (t) value at the significance level (0.05) and degree of freedom (18) is (2.10). The results show that there are no significant differences in variables, indicating the parity of the two sample groups (see Table 4).

*Measures*

This quantitative study used several research methods to access the required research data and results, which are scientific sources and references, tests and measurement. After reviewing the football academic curriculum and scientific references, a number of core competencies were identified and put into the form of a questionnaire which was presented to a group of experts in the field of education, tests and measurements in football. The most important basic skills: running with the ball, hitting the ball with different parts of the foot, hitting the ball with the head, throwing.

Also, after identifying the important and appropriate football skills for the students of the research sample, special and appropriate tests for these skills were fixed and then presented to a group of experts. (75%) or more from the opinions of specialists, and the tests that have been approved are: (i) running a football test between (5) signs to measure the ability to control the ball; (ii) test kicking the ball with different parts of the foot farthest away; (iii) heading test for stability and movement; (iv) the farthest throw-in test. Thus, the basic skills tests used in the current research are standardized tests, and according to scientific sources, the standardized test (if an experiment is used for samples similar to the sample to be tested, prove a high degree of significance in terms of validity, consistency and objectivity under the same conditions and capabilities available), and in this study the tests are prepared. The used tests are standardized and appropriate for the research sample, as they have been applied in previous and similar studies that have been touched upon.

Data were collected through the devices and tools (1) devices: a weighing scale, an electronic stopwatch, count; (2) tools: tape measure, footballs, whistle, and funnel. In relation to the homogeneity and equivalence of the research sample: the researcher, together with the assistant work team, conducted a number of exploratory experiments

**Table 2.** The experimental design of the two research sample sets

| The group | Pre-test and equivalence of the two research groups | Independent variable | The post test between the two research groups (dependent variable) |
|---|---|---|---|
| Experimental (1) | Age, weight, height. Running with the ball, kicking the ball, heading the ball, throwing in | Competitive method | Running with the ball, kicking the ball, heading the ball, throwing in |
| Experimental (2) | | Stations style | |

**Table 3.** The statistical parameters of the age, weight and height variables for the two research sample groups

| For measurements | The first experimental group | | The second experimental group | | Calculated (t) value |
|---|---|---|---|---|---|
| | p | sd | p | sd | |
| Age / year | 0.721 | 19.00 | 0.816 | 19.00 | 0.949 |
| Weight / kg | 1.436 | 65.40 | 1.573 | 67.20 | 0.636 |
| Height / cm | 2.180 | 170.20 | 2.097 | 171.80 | 0.363 |

**Table 4.** The basic variables for football skills of the two research groups

| The exams | The first experimental group | | The second experimental group | | Calculated (t) value |
|---|---|---|---|---|---|
| | p | sd | p | sd | |
| Running by ball / sec | 0.921 | 19.830 | 0.787 | 20.100 | 0.704 |
| Kick the ball to different parts / degree | 0.788 | 9.800 | 1.316 | 10.200 | 0.824 |
| Heading / Score | 1.686 | 8.800 | 1.699 | 9.000 | 0.264 |
| Throw in / score | 8.164 | 000. 60 | 8.432 | 64.000 | 0.078 |

on (10) students from the research community and outside the research sample.

*Procedures*

First of all, the permission was granted by the director of university of Benghazi and teachers to realize the current study. Then, the educational plan for teaching was implemented in a competitive manner and stations. There was an educational plan for each of them during (8) weeks, according to a weekly educational plan for each group, and according to a lecture every week, as the time of the lecture was two hours every day (Saturday) of each week, where the first experimental group used the lecture plan in a competitive manner, and the second experimental group used the content of the lecture in the method of stations. The students of the two groups of the research sample received instruction in the recreation classes of the Faculty of Physical Education of the University of Benghazi, and the implementation of the experiment lasted two months. In addition, post-tests were conducted on the students of the two sample groups after completing the implementation of the two methods, in order to determine the level of basic skills that the students of the two sample groups.

*Statistical Analysis*

Analyses were performed using statistical software SPSS 23 (Statistical Package for social science) program. The following variables were calculated using: Arithmetic mean, Standard deviation, Simplex correlation coefficient (Pearson), T-test for two unrelated averages for two equal samples and T-test for two related means for two equal samples.

## Results

*The effect of using the competitive teaching method*

*The first experimental group (the competitive teaching method)*

The results of the first question: What is the effect of using the competitive teaching method on learning some basic football skills for students of the first experimental group at the Faculty of Physical Education and Sports Sciences at the University of Benghazi? emerged from the data collected were illustrated in Table 5. Significant when the error ratio ⩾ (0.05) and before the degree of freedom (9) and the tabular value of (t) = (2.26). It is evident from the above table that the calculated values of (t) appeared greater than the value of (t) scheduling, significant differences were also found in favor of the post-test.

*The second experimental group (the teaching stations method)*

The results of the second question: What is the effect of using the method of teaching stations on learning some basic football skills for students of the second experimental group at the Faculty of Physical Education and Sports Sciences at the University of Benghazi? emerged from the data collected were illustrated in Table 6. The results indicate that the calculated values of (t) appeared greater than the

**Table 5.** The measurement of some basic football skills for the first experimental group

| Basic skills | Measuring unit | Tribal measurement | | Dimensional measurement | | Calculated (t) value |
|---|---|---|---|---|---|---|
| | | sd | p | sd | p | |
| Running with the ball | Second | 19.830 | 0.921 | 16.980 | 0.675 | 10.377 * |
| Kick the ball with different parts of the foot | Degree | 9.800 | 0.788 | 13.200 | 0.632 | 9.160 * |
| Heading the ball | Degree | 8.800 | 1.686 | 11.800 | 1.475 | 4.881 * |
| The throw-in | Degree | 60.000 | 8.164 | 76.000 | 5.163 | 5.237 * |

Note: * Significant when the error ratio ⩾ (0.05) and before the degree of freedom (9) and the tabular value of (t) = (2.26).

**Table 6.** The measurement of some basic football skills for the second experimental group

| Basic skills | Measuring unit | The pretest | | Post test | | Calculated (t) value |
|---|---|---|---|---|---|---|
| | | sd | p | sd | p | |
| Running with the ball | Second | 20.100 | 0.787 | 18.590 | 0.814 | 3.784 * |
| Kick the ball with different parts of the foot | Degree | 10.200 | 1.311 | 12.100 | 0.632 | 3.994 * |
| Heading the ball | Degree | 9.000 | 1.699 | 10.600 | 1.349 | 2.753 * |
| The throw-in | Degree | 64.000 | 8.432 | 69.000 | 7.378 | 3.000 * |

Note: * Significant when the error ratio ⩾ (0.05) and before the degree of freedom (9) and the tabular value of (t) = (2.26).

**Table 7.** The statistical differences in developing some basic football skills

| Basic skills | Measuring unit | The first experimental group | | The second experimental group | | Calculated (t) value |
|---|---|---|---|---|---|---|
| | | sd | p | sd | p | |
| Running with the ball | Second | 16.890 | 0.675 | 18.590 | 0.814 | 5.080 * |
| Kick the ball with different parts of the foot | Degree | 13.200 | 0.632 | 12.100 | 0.994 | 2.271 * |
| Heading the ball | Degree | 11.800 | 1.475 | 10.600 | 1.349 | 2.897 * |
| The throw-in | Degree | 76.000 | 5.163 | 69.000 | 7.378 | 2.458 * |

Note: * Significant when the error ratio ⩾ (0.05) and before the degree of freedom (18) and the tabular value of (t) = (2.10).

value of (t) scheduling, which indicates the presence of significant differences in favor of the post-test.

*Impact on developing some basic football skills*

The results of the second question: Are there statistically significant differences in the telemetry between the first experimental group and the second experimental group in developing some basic football skills? emerged from the data collected were illustrated in Table 7. The measurement shows that the calculated values of (T) appeared greater than the value of (T) scheduling, and this indicates the existence of significant differences between the members of the two groups.

## Discussion

To provide a training quality in terms of teaching practice for student-trainees that meet the challenges and requirements in movement and activity and learning skills. Thus, the purpose of this research was to know the possibility of the sample to apply tests for competitive method and stations are believed to be important for a successful teaching and training in football performance and motor skills.

According to our results, there are significant differences between the results of the basic skills tests, before and after, for two experimental groups. Therefore, we refer the reasons for these differences in basic skills to the effectiveness of the educational plans applied to the students of the first two experimental groups who use the competitive method, and the second who uses the station method. Also, the choice of exercises aimed at teaching these skills and the organization of the skills listed in each teaching plan. Moreover, the optimal investment of real time allocated to the implementation of motor duty, which leads to an increase in real practice by participating in the performance of all students, which has led to an increase in movement and activity and learning these skills. According to Mujika et al., [27] sports training is a complex action exerting a systematic and specific effect on the level of sports performance and the capacity for optimal performance in a situation of test and competition. Thus, the relationship between the motor skills, which are the general prerequisites of the performance, and the motor skills which are the automated patterns of the sports discipline considers, constitutes the basis of the relationship general load / specific load [28, 29]. In this context, Gréhaigne et al. [30] confirm that the use of lesson time to increase performance and motor skills will allow learners to develop many physical, motor and motor skills. The ability to stabilize this learning is not an easy process, so it is necessary to practice correctly. To benefit from it in other situations similar to this acquired skill [31]. The students' interaction with these exercises helped increase the excitement of Lal's lesson and this is what he pointed out. The competitive learning method provides students with opportunities for competition, enthusiasm and effective participation in assigned tasks, as well as the initiative and collective responsibility of each group when implementing skills, increases the student interaction with each other. This leads to the learning of skills within the group and reinforces the desire to learn the skills and be effective [32, 33]. Finch et al. [34] highlight the importance of training programming and its content. It states that it is a systematic planning process based on practical experience and sports science knowledge of structuring (long-term) training according to a training objective and individual level of performance. As a result, the development of the various training programs can be designed as a coaching program, a collective or individual program, over several years or annually, over a long cycle or on a training unit [35, 36, 37, 38]. In addition, the individual training program contains the fundamental guidelines that will allow you to achieve optimal performance. It defines the objectives, tasks, contents, means, methods, organization, evaluations and competitions [19, 20, 21, 39].

Our results, also, showed (see Table 7) there are statistically significant differences between the scores of the experimental groups and the second in all the basic skills in the game of football in

favor of the first experimental group applied in the competitive method. It is believed that the reasons for these differences in basic skills were in favor of the first experimental group. In the competitive method are the exercises aimed at developing the basic skills in a competitive way, as well as the exercises used in the lecture had a clear objective, which facilitated the work of the students. Thus, repeating the exercise several times allows the student to master the skill and perform it better correctly during the game. This method provided the students with a similar atmosphere of the match and motivates them in training the basic skills. It comes out that competition is one of the procedural method which pushes the relative activity, helps the process of education and training, make known the characteristics of the competitor and his strengths and weaknesses by practicing with a colleague during execution skills. This is one of the main points to improve the performance level of skills, unlike activities that are not characterized by direct competition, which has less effect due to the absence of a competitive factor. In football, a physical quality is a global characteristic of motor skills, and an individual only possesses it if he is able to mobilize it in most situations encountered. This quality is therefore endowed with a transferable and operational nature, which will facilitate the acquisition and quality of motor learning. In this sense, Manno [28] distinguishes three major types of motor capacities (i) conditional capacities: are based on the metabolic efficiency of muscles and apparatus: strength, endurance and speed, (ii) coordinative capacities: are determined by the neuromuscular mechanisms allowing to organize and regulate the movement: the address, (iii) Intermediate abilities: flexibility and simple reaction speed. From this, Karalejic et al. [40] distinguish two main types of physical qualities: (i) the factors depending mainly on physical condition (and energy processes): endurance, strength and speed, (ii) factors mainly dependent on the control processes of the nervous system – flexibility and the ability to coordinate. In recent years, there has been a growing number of studies on the types of training specific to football. It is within this development that we notice a strong emphasis on the effects of reduced games [41]. Gréhaigne [42] suggests taking into account the internal logic of reduced games, which means that the player must highlight his performance qualities, in a permanent uncertainty of the opponent and his partners. In addition, reduced play retains important elements of tactical complexity, but allows execution with a level of physical demands (smaller space) and greater time (lower player density) that better matches the level of beginners [43].

## Conclusions

This article focuses on the effect of two different teaching methods, which are represented in the collective competitive method and the station method in teaching some basic football skills to students, and encourage teachers to use two styles. After presenting, analysing and discussing the results, the researcher reached the following conclusions:

(i) the competitive method made a remarkable development in all basic skills (running with ball, kicking the ball with different parts of the foot, hitting the ball with the header, throwing in);

(ii) the latest stations style marked development in all basic skills (running with ball, kicking the ball with different parts of the foot, hitting the ball with the header, throwing in);

(iii) the competitive style surpassed the stations method in the post tests in all basic skills.

In light of the researcher's conclusions, the researcher recommends the following: emphasizing the use of two styles (competitive and station style) in developing basic football skills, organizing units so that they achieve the principle of continuity through succession between skill parts, and teaching newly experienced students on methods teaching that depends on the method of competition and stations during preparation and development cycles, and conducting similar research using multiple methods in different study stages according to other study subjects.

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*The journal represents original scientific researches of scientists from the East-European region.*
*The Journal welcomes articles on different aspects of physical education, sports and health of students which cover scientific researches in the related fields, such as biomechanics, kinesiology, medicine, psychology, sociology, technologies of sports equipment, research in training, selection, physical efficiency, as well as health preservation and other interdisciplinary perspectives.*

*In general, the editors express hope that the journal "Physical Education of Students" contributes to information exchange to combine efforts of the researchers from the East-European region to solve common problems in health promotion of students, development of physical culture and sports in higher educational institutions.*

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PHYSICAL EDUCATION OF STUDENTS

ORIGINAL ARTICLE

# Theoretical and applied perspectives of the kinesiology discipline in the field of physical education and sports science

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Authors' Contribution: A – Study design; B – Data collection; C – Statistical analysis; D – Manuscript Preparation; E – Funds Collection

**Abstract**

*Background and Study Aim* The study intends to estimate the theoretical and applied perspectives of the Kinesiology discipline in the field of Sport and Physical Education science.

*Material and Methods* A total number of 127 subjects (students of the Physical Education and Sport Department in the University of Pitești) participated in this research. There are 59 students in Physical Education and Sport (PES), 37 in Sport and Motor Performance (SMP) and 31 in Physical Education and Sport Conversion (PESC). The research was conducted during COVID-19 pandemic, in the academic year 2021-2022. The teaching and evaluation activity in the Kinesiology discipline was carried out online by means of Zoom program. The monitoring of the teaching activity was done with the help of the university e-learning platform. The opinions of the subjects on the discipline taught and the assessment of the teaching staff by the students were analyzed using Google Forms questionnaire. The fundamental basic knowledge in Kinesiology was evaluated using the following indicators: S1 (periodically evaluated activities) = A1 (40%) +A2 (20%), final evaluation (FE) – examination (40%), S2 – sum of the fractions of grade obtained at the periodic evaluations and those from the final verification.

*Results* The analysis of the subjects' opinions regarding the topic of the discipline taught reveals 5% moderate opinions, 16% - good and 79% very good ones. The evaluation of the basic fundamental knowledge in Kinesiology highlights the following values of the indicators: A1 (40%) – an average of 8.05 points between groups ($p<0.01$); A2 (20%) - an average of 7.95 points ($p>0.05$); S1 – an average of 4.81 points ($p<0.05$). The final evaluation (40%) in the exam shows an average of 3.36 points ($p<0.01$); S2 has 8.17 points ($p<0.01$); the final grade between groups has an average of 8.29 points, with differences of rounding in student's favor ($p<0.05$). The analysis of students' opinions concerning the teaching activity in Kinesiology discipline shows that 76% rate it as excellent, 14% - very good, 6.7% - good, 1.9% - satisfactory and 1.4% unsatisfactory (extracurricular activity).

*Conclusions* There were shown the subjects' opinions on the Kinesiology discipline topics and the weight of meeting the minimum and maximum performance standards. The preferred or practiced sports chosen in the researched study programs were presented. The results of the evaluation of the basic fundamental knowledge highlight the value of the averages between groups for the evaluated indicators. These results also reveal the opinions of the students about the didactic activity carried out by the professor in the discipline studied.

**Keywords**: didactic activity, knowledge, opinions, teaching, evaluation, performance standard.

## Introduction

Kinesiology is a general theory of body movement that studies physical activity and its impact on health, life quality, society and human performance [1]. Kinesiology is a young discipline with rapid evolution. It is an overall vision of the means, methods, forms of organization and directions to use the physical exercise. This discipline can be approached from the perspective of a wide range of viewpoints [2, 3, 4]. Kinesiology applies the scientific principles borrowed from fields with which it collaborates in terms of human movement. It is the case, for example, of the anatomical-functional field,


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the physical availability, biomechanical and medical fields, sport philosophy and psycho-pedagogical field [3, 5, 6, 7].

Kinesiology is a combination of a complex of theoretical and practical disciplines related to physical activity. It is conventionally and didactically constituted through an interdisciplinary approach. Kinesiology is included in the curriculum of the Romanian specialized higher education in order to develop the skills of the future specialists in the field of Sport Science and Physical Education (SSPE). There are three programs of study: Physical Education and Sport (PES) for Teachers; Sport and Motor Performance (SMP) for Coaches; Kinesiotherapy and Special Motricity (KSM) for Kinesiotherapists. In Romania, the most numerous works (books and university courses) about this field of study were written by doctors and kinesiotherapists. They used kinesiology as an academic scientific discipline, but they emphasized on its therapeutic – medical part.

The approach of all sides of kinesiology with the support of specialists from all constitutive subfields can be a success in creating a complex work with international recognition. The most prestigious reference works are the approaches made by the *Human Kinetics* Publishing House through the agency of foreign authors and also *Romanian authors* [5]. The works of all these authors were the sources of inspiration for the subject matters in Kinesiology discipline.

Kinesiology at its best is an integrative academic discipline which can help to lead the way in crossing boundaries in higher education [8]. There are trends in the modern science that will influence the future of the kinesiology through improvements of the scientific specialization. Also, the focus on „bigger impacts" of the funded research, the new types of peer reviews, the advanced technology will increase the complexity and integration of kinesiology [9]. A general look on the specialized literature and its definitions specific to kinesiology highlight the interdisciplinary and intradisciplinary research. Examples of interdisciplinary research projects are given. The importance of both teaching and the interdisciplinary services is also approached [10].

*Purpose of the Study*. The study purpose was to estimate the theoretical and applied perspectives in the Kinesiology didactic activity in the field of Sport and Physical Education science.

## Materials and Methods

*Participants*

An experimental study on the teaching and evaluation in" Kinesiology" discipline was conducted to identify the fundamental elements necessary for the scientific research activity. The study was carried out at undergraduate level in the following academic programs: Physical Education and Sport (PES), Sport and Motor Performance (SMP), Physical Education and Sport Conversion (PESC).

This research was done with the participation of the students of the Physical Education and Sport department within the Faculty of Sciences, Physical Education and Informatics (the University of Pitești). The total number of subjects was n=127 (namely, 59 from PES, 37 from SMP and 31 from PESC). All subjects were informed and gave their consent to voluntarily participate in the research, respecting the Declaration of Helsinki and the decisions of the Department Commission of Ethics.

*Research Design*

The research was conducted along one semester during COVID-19 pandemic period, the academic year 2021-2022. It included 14 weeks with 2 hours of course (C) and 2 hours of seminar (S).

The content of the Kinesiology discipline was monitored by means of the e-learning platform of the university. The teaching and evaluation activity was carried out online, using the Zoom program.

The activity during seminar (A) involved writing a paper on topics from the practiced or preferred sport, depending on the study program. The project / paper was structured in 4 chapters:

1. Motivation for choosing the sports branch;
2. Specific motor fitness – physical training (5 exercises of general physical training and 5 specific exercises);
3. Technical training (systematization and exemplification);
4. Notions of the regulation.

For the evaluation of the discipline basic knowledge, the requirements of the sheet for each study program and the instructions on the evaluation rules in the credit system and on the class book filling were respected:

- number of weeks of the semester: 14;
- total number of hours of the semester: 125 hours;
- number of hours according to the curriculum: 56 hours (28 hours C and 28 hours S);
- total number of hours of individual study: 69 hours;
- number of credits: 5;

S1 – sum of the fractions of grade obtained for the periodically evaluated activities (A1+A2);

A1 (40%), S – the ability to operationalize knowledge, capacity for practical application, attitudinal criteria, seriousness, conscientiousness, interest in the individual study;

A2 (20%) active participation in at least 60% of the practical activity (S), repeated participation in the debate, presentation of homework and personal points of view (developed through study) on the topic;

- presentation of a portfolio according to the

minimum requirements for S and the homework for C (Paper);

Final Evaluation (FE): written exam, evaluation criteria at C – correctness and complexity of knowledge, logical coherence, level of assimilation of the specialized language;

S2 (40%) – sum of the fractions of grade obtained for the periodic evaluations and those from the final verification.

The GRADE is obtained by rounding the S2 sum to the whole, in favor of the student, except for the values between 4.50...4.99 where the rounding is done to 4.00.

The periodic evaluation was performed by grading the content of the papers from 1 to 10 points. The share from the final grade was calculated by multiplying the grade by the % corresponding to the requirements.

At the end of the semester, a questionnaire was used with the help of the Google Forms application. The questionnaire was addressed to the students in the study and focused on their opinions regarding the topics of the Kinesiology course. The students assessed the teaching staff by means of a questionnaire consisting of 6 indicators:

1. Quality of didactic activity (CAD);
2. Use and efficiency of the teaching aids in the education process (UEMD);
3. Involvement of the students in their own training (ASPF);
4. Professor -student relationship (RS-P);
5. Objectivity and transparency in evaluation (OTE);
6. Ability to involve the student in extracurricular activities (CASAE).

Grades awarded: 1 - unsatisfactory; 2- satisfactory; 3 - good; 4 – very good; 5 – excellent.

*Statistical Analysis*

The statistical indicators were calculated using the KyPlot 6.0 program (©1997-2020, KyensLab Inc), regarding the mean and standard deviation. The nonparametric Kruskal-Wallis Test was used to calculate the differences in means between several irregular samples. Statistical significance was set at $p < 0.05$.

## Results

40% subjects from the PES and SMP study programs participated in the assessment of students' opinions on the content of Kinesiology discipline. 92.1% of these subjects practiced performance sports while 7.9% did not.

The analysis of the research subjects' opinions regarding the topic of the discipline taught reveals 5% moderate opinions, 16% - good ones and 79% very good ones. Regarding the control of body oscillations and positions in the movements automation, 50% (PES) consider that it is achieved through the repetitions characteristics, while 52.6% (SMP) - through the effort-rest ratio. As for the subject matter of Structural Kinesiology, 47.3% take into consideration the morphological and functional support of the motricity. In the case of the Biomechanics of sports and physical exercises, 55.2% have a very good opinion, considering it as a factor favoring the increase of the adaptive effect and the elimination of the physical exercising risks. With regard to the Medical Kinesiology (PES and SMP), 57.8% are in favor of its application with therapeutic purpose and 60.5% - prophylaxis through movement. Concerning the fulfilment of the minimum standard of performance, the subjects answered as follows: 36.5% - definition of basic concepts; 34.6% - general classification and systematization; 28.9% - limited operationalization. Regarding the fulfilment of the maximum standard of performance, the opinions were divided like this: 31.6% - integrative, complex concept on the physical exercise knowledge and practice; 33.3% - presentation of relevant information on the course

**Table 1.** The weight of subjects' opinions on the topics covered by the Kinesiology course (n=38).

| No. | Topics of the course | Grades (%) | | |
|---|---|---|---|---|
| | | 3 | 4 | 5 |
| 1 | Physical exercise – health status (1) | - | 13.2 | 86.8 |
| 2 | Physical exercise – special form of manifestation of human movement (2) | - | 18.4 | 81.6 |
| 3 | Classification of sports branches according to different criteria (3) | 2.6 | 21.1 | 76.3 |
| 4 | Kinesiology applied to adapted fitness – therapeutics (5) | 5.3 | 18.4 | 76.3 |
| 5 | Kinesiology applied to general fitness, sport as a physical activity, tourism and leisure (6) | 5.3 | 18.4 | 76.3 |
| 6 | Kinesiology applied to specific motor fitness– Sports kinesiology (7) | 5.3 | 13.2 | 81.6 |
| 7 | Physiological effects of sport and physical activity (11) | 5.3 | 13.2 | 81.6 |
| 8 | Psychology of practicing physical exercise (12) | 2.6 | 21.1 | 76.3 |
| 9 | Importance of the content of the taught discipline and its necessity for the professional training (13) | 7.9 | 13.2 | 78.9 |

3 – moderate opinion; 4 – good opinion; 5 – very good opinion

topics, through the bibliographic reviews studied or a paper as homework; 35.1% - identification and presentation of originally and competently composed models for knowledge application, by exemplifying some real practical situations.

Figure 1 shows the sports preferred or practiced by the subjects-participants in the research, according to the paper written for the Kinesiology discipline. Thus, 22.7% of the participants preferred or practiced sports were selected within all the programs of study. It is the case of the following sports: *football* by 35% in PES, 9.40% in SMP and 29.70% in PESC; *basketball* by 11.90% in PES, 21.90% in SMP and 18.50% in PESC; *athletics* by 5.90% in PES, 9.40% in SMP and 3.70% in PESC; *handball* by 13.70% in PES, 3.10% in SMP and 7.40% in PESC; *swimming* by 5.90% in PES, 6.30% in SMP and 3.70% in PESC.

The basic fundamental knowledge in Kinesiology was evaluated observing the requirements of the subject matter sheet and the instructions on the evaluation in the credit system and on class book filling. The comparative results per programs of study are shown in table no. 2.

The analysis of the statistical calculation results reveals the values as follows: for the indicator A1 – a mean of 8.05 points between groups, with 22% in PES, 21.5% in SMP and 12.75% in PESC until reaching the score of 40% ($p<0.01$). As for the indicator A2 (20%), there is a mean of 7.95 points between groups, with 21.5% in PES, 21.5% in SMP and 16.5% in PESC till reaching the maximum score of 20% ($p>0.05$). The indicator S1, referring to the periodically evaluated activities, has the following values: a mean of 4.81 points (A1+A2) with 21.8% in PES, 21.5% in SMP and 13.8% in PESC until the cumulative score of 60% ($p<0.05$). Concerning the final exam evaluation, a total mean of 3.36 points is noticed, with 18.25% in PES, 17.25% in SMP and 9.75% in PESC until obtaining a score of 40% ($p<0.01$). The indicator S2 shows the sum of the fractions obtained at the periodical evaluations (S1)

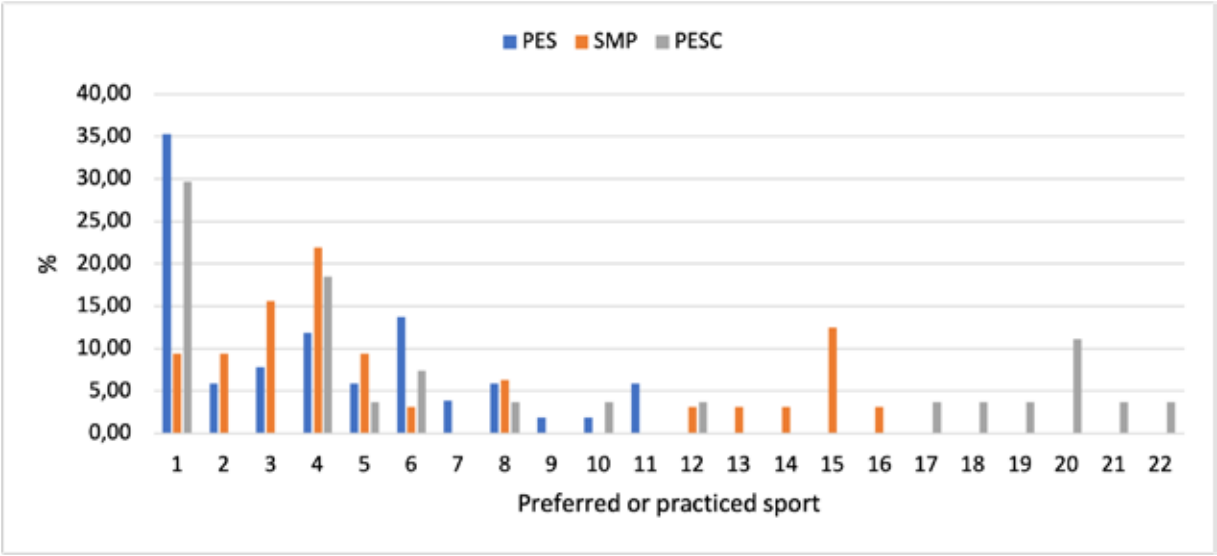


**Figure 1.** Weight of the sports branch selection by the subjects participating in the study. PES - Physical Education and Sport; SMP - Sport and Motor Performance; PESC - Physical Education and Sport Conversion; 1 – Football; 2 – Tennis; 3 – Karate; 4 – Basketball; 5 – Athletics; 6 – Handball; 7 – Fitness; 8 – Swimming; 9 – Wrestling; 10 – Volleyball; 11 – Theory knowledge; 12 - Skiing; 13 – Sledge; 14 – Judo; 15 – Kayac; 16 – Canoe; 17 - Football-tennis; 18 – Bodybuilding; 19 – Skating; 20 - Artistic gymnastics; 21 – Fencing; 22 - Taekwon-do ITF.

**Table 2.** Results of the evaluation of the basic fundamental knowledge in Kinesiology, n = 127.

| Variables | | PES (*n* = 59) | SMP (*n* = 37) | PESC (n = 31) | Chi - Square | *p*-Value |
|---|---|---|---|---|---|---|
| A1 (40%) | pts | 3.12 ± 0.6 | 3.14 ± 0.5 | 3.49 ± 0.4 | 10.24** | 0.006 |
| A2 (20%) | pts | 1.57 ± 0.3 | 1.57 ± 0.3 | 1.67 ± 0.2 | 2.86 | 0.239 |
| S1 | pts | 4.69 ± 0.8 | 4.71 ± 0.8 | 5.17 ± 0.6 | 8.20* | 0.016 |
| EF (E, 40%) | pts | 3.27 ± 0.5 | 3.31 ± 0.5 | 3.61 ± 0.3 | 10.44** | 0.005 |
| S2 | pts | 7.96 ± 1.3 | 8.02 ± 1.3 | 8.75 ± 0.9 | 9.22** | 0.009 |
| Final grade | grades | 8.05 ± 1.5 | 8.19 ± 1.4 | 8.87 ± 0.8 | 6.89* | 0.031 |

Values are expressed as means ± standard deviations. Nonparametric Kruskal-Wallis Test; *p<0.05; **p<0.01;

**Table 3.** Weight of students' opinions regarding the didactic activity carried out at Kinesiology (n=46).

| No. | Evaluation criteria | Grades (%) | | | | |
|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 |
| 1 | CAD | - | 4.4 | 7.2 | 17.4 | 71 |
| 2 | UEMD | - | 1.4 | 7.2 | 14.6 | 76.8 |
| 3 | ASPF | - | 1.4 | 7.2 | 8.7 | 82.7 |
| 4 | RS-P | - | 1.4 | 5.8 | 13.1 | 79.7 |
| 5 | OTE | - | 1.4 | 7.2 | 15.9 | 75.5 |
| 6 | CASAE | 1. 4 | 1.4 | 5.8 | 18.9 | 72.5 |

Grades: 1 – unsatisfactory; 2 – satisfactory; 3 – good; 4 – very good; 5 – excellent. 1. Quality of didactic activity (CAD); 2. Use and efficiency of the teaching aids in the education process (UEMD); 3. Involvement of the students in their own training (ASPF); 4. Professor -student relationship (RS-P); 5. Objectivity and transparency in evaluation (OTE); 6. Ability to involve the student in extracurricular activities (CASAE).

and those from the final check (examination): a total score of 8.17 points was obtained. The differences in reaching the maximum score are: 20.4% in PES, 19.8% in SMP and 18.3% in PESC ($p<0.01$). The final grade between groups has a mean of 8.29 points. Thus, the mean of the grade is 8.05 points in PES, 8.19 points in SMP and 8.87 points in PESC. These differences are due to the rounding of the value of units in favor of the student ($p<0.05$).

In order to assess the didactic activity carried out in the Kinesiology discipline, a questionnaire was given to the students who had a joint activity with the teaching staff (course / seminar) during the semester. The weight of the opinions is presented in table no. 3.

The analysis of students' opinions on the didactic activity within the Kinesiology discipline highlights that 76% rate it as excellent, 14% - very good, 6.7% - good, 1.9% - satisfactory and 1.4% unsatisfactory (extra-didactic activity).

## Discussion

An experimental study was carried out for identifying the basic elements required by the scientific research activity related to the teaching and evaluation in "Kinesiology" subject. The research focused on the PES, SMP and PESC undergraduate study programs of the Physical Education and Sport Department from the Faculty of Sciences, Physical Education and Informatics of the University of Pitești.

Kinesiology is an academic discipline included in the curriculum of the specialized higher education in Romania in order to develop the skills of the future specialists in the field of Sport Science and Physical Education (SSPE). A large number of works on Kinesiology as academic scientific discipline were created by physicians and kinesiotherapists who emphasized on the therapeutic – medical part of the field. The review of the specialized literature highlighted the concerns existing in this direction.

Kinesiology is a diverse field based on the scientific understanding of health and body in motion; it is centered on a core ideology of the physical activity. Due to its multidisciplinary nature, kinesiology is a field that is made for interdisciplinary collaboration [4, 5, 6, 11]. Kinesiology is an academic discipline whose content can be used to support professions and to solve important issues of the public health. This support is ensured by two teams of research and education that deal with the exercise physiology and the exercise behavior science [12]. Moreover, the ethics courses in kinesiology are mainly based on the Eurocentric philosophies and legal paradigms. These are: (a) social justice; (b) vulnerability of the practitioner; (c) relationships in a social-political-historical context, alongside the traditional ethical principles of (d) autonomy; (e) benevolence; (f) non-maleficence [13]. Academic and career choices involved the kinesiology and, in particular, the psychology of sport and physical exercises [14]. A recent study highlights a significant lack of racial diversity in the academic programs of kinesiology in Canada [15]. High-impact practices sustain the success of students, even though the faculty may face difficult teaching tasks, insufficient resources and absence of infrastructure. A study was conducted within the Kinesiology Faculty of California State University, East Bay where two student programs were implemented: Kinesiology Research Group and Get Fit! Stay Fit! The students confirmed the value of these programs for their academic and professional development [16]. Other studies justified the introduction of the theories of adaptive, complex and transformational leadership into the practice of the kinesiology leader.

Given that the research has been conducted for one semester during the pandemic period of COVID-19, the monitoring of the Kinesiology content has been made with the e-learning platform of the University of Pitești. The activity of teaching and evaluation were carried out online.

The impact of the pandemic, which affected the way students and teaching staff approached

curriculum and pedagogy, was also analyzed [17]. Careers in kinesiology field could start with a master in professional services, focused on fitness productivity and innovation. Graduates with athletic training or authorization in sports medicine might work in schools or professional sport organizations [18]. In any sport, competition is essential. It is the objective way to turn into good account the performance capacity of the athletes. The pandemic generated by Covid 19 deprived all sports, dance sport included, of everything that meant a specific competitive context. The national and international competitions have been cancelled for a long period and everybody missed the enthusiasm and joy of both athletes and audience [20].

The results regarding the views of the participants in the research about the topics of the Kinesiology discipline highlight 79% very good opinions. The basic concepts with which kinesiology operates refer to physical activity, exercise, fitness, health and well-being. A study provides an update on the Psychology of Sport chapter, including key developments, topics and issues in the psychology of sport and exercise [21]. In recent decades, the impact of doping in sport has grown exponentially. Every year, the fight against this type of irregularities is intensifying to protect the rights of the athletes and the integrity of the sport values [22]. Structural kinesiology studies the origin and support of human movement in the context of the relation between the musculoskeletal and articular system and the neuro-muscular system.

Another chapter from the subject matters of the Kinesiology refers to the Biomechanics of sport and physical exercises. 55.2% of the students participating in the research have a very good opinion about this subject. They consider it as a favorable factor for increasing the adaptive effect and eliminating the risks of physical exercise practice. Kinesiology uses knowledge of biomechanics with the purpose to increase sports performance by optimizing the execution technique. Some of the methods used for movements study: anthropometry; video and image analysis techniques; optoelectronic techniques; platforms of force, pressure and balance; electromyography; dynamometry. There are also used global localization systems and remote measurements of some physiological components in real time [5, 11, 12]. Other paper provides an overview of various research topics and analyzes the influence of the motor learning on other fields of study. It also takes into consideration the future of the motor learning research both within and outside the academic study of kinesiology [19]. The present orientations in the implementation of the biomechanics research and their scientific impact are shown through the interdisciplinary approach. Modern teaching technologies are used during the training sessions and the competition performances are turned into good account [23]. The new concept of human movements study during sports and physical training is mainly based on methodical techniques such as the system biomechanical analysis. The analysis of movements using the biomechanical principles helps to understand that the final result of the action is determined by the systemic unity of the goals achieved. The coach must insist on the importance of a holistic perception of the action, taking into consideration the cause-effect relations between the motor action phases [24].

As for the thematic chapter "Medical Kinesiology", 57.8% of the respondents (from PES and SMP) have a very good opinion regarding its use for therapeutic purpose while 60.5% (PES and SMP) for using it as prophylaxis through movement. In this sense, Medical (or therapeutic) Kinesiology (adapted fitness) deals with the type of physical activity related to therapy. It aims at achieving a fitness level adapted to the needs and the limited movement/functional possibilities of the patients. The current concept regarding occupational therapy treatment for children involves their preparation for the role of adult. They are trained by activities appropriate to their functional development, meant to correct any type of disability [25]. The football players are often subject to lower limbs injuries because they jump and land frequently or they turn around while decelerating. One of the most frequent injuries is at knee level [26].

76.3% of the students (PES and SMP) have very good opinions on the chapter "Kinesiology applied to the general fitness", namely the kinesiology in relation to health – exercises and activities of a general nature.

Regarding the "Kinesiology of motor fitness" (specific one) that is associated to performance, very good opinions are expressed by 81.6% of the students (PES and SMP). Some studies analyze the current performances in dance sport highlighting the human motor excellence as a synthesis of the bio-psycho-motor skills. The psychomotor skills are very important for the technical and artistic achievement of dance steps and figures. Therefore, it is essential to analyze the dance influence on the development of motor skills, such as the capacity for ambidexterity and laterality [27].

According to the paper prepared by the participants in the research for the "Kinesiology" discipline, 22.7% of the sports preferred or practiced were selected in all the programs of study.

Referring to basketball, it was chosen by 11.90% students in PES, by 21.90% in SMP and 18.50% in PESC. A study dealing with the analysis of the performance presents the efficiency of the specialized training program in basketball. This efficiency can be also checked by analyzing some statistical indicators resulted from the official games of the Romanian women's basketball team [28].

The handball was selected by 13.70% students in PES, 3.10% in SMP and 7.40% in PESC. Given the rapid evolution of handball and the specific fitness approach, specialists must address all aspects related to the basic motor skills and the training components. These ones can be applied both at team level and individually, to the players specialized in certain game positions [29].

With regard to athletics, this sport was chosen by 5.90% students in PES, 9.40% in SMP and 3.70% in PESC. Taking into consideration the approach of Kinesiology aspects, a study analyzes the triple jump as one of the most complex and demanding events in athletics. Triple jump requires a continuous development of the technique and motor skills. It also needs the development of some perceptual-cognitive components, which are not sufficiently explored in the specialized studies [30].

The combat sports were selected as follows: 7.80% of the students in PES program chose Karate and 1.90% chose wrestling. 15.60% of the students in SMP chose Karate and 3.10% chose Judo. Regarding the PESC program, 3.70% of the students chose Taikwando. In this respect, an analysis of the specialized literature on the methodology of strength training in wrestling was made. It reflects the importance of the manifestation of maximum and explosive strength. The strength endurance can be developed through pulls up, bench press, push-ups, barbell jerk, barbell squats, throws of a medicine ball, high and long jump, rope climbing etc. [31]. The theoretical analysis of the wrestlers' training process showed the methods and means necessary for developing their strength skills according to the sports modern training principles [32].

The evaluation of the basic knowledge in "Kinesiology" was carried out according to the subject matter requirements. The instructions on the evaluation rules in credit system and on the class book filling in the University of Pitești were also taken into account. In terms of achievement of the performance minimum standard, the students answered as follows: 36.5% of them – definition of the basic concepts; 34.6% - general classifications and systematizations; 28.9% - limited operationalization. Regarding the maximum standard of performance, the following answers were given: 31.6% - integrative concept; 33.3% - presentation of relevant information on the course topics; 35.1% - identification and presentation of practical real situations. Given that each institution in Romania has its own grading and evaluation methodology, there were not found studies published in this regard, excepting the own studies recently conducted in the scientific research methodology field [33].

## Conclusions

The paper presented the opinions of the subjects regarding the "Kinesiology" discipline topics and the achievement of the minimum and maximum performance standards.

It was shown the share of the preferred or practiced sports chosen in all programs of study within the "Kinesiology" project elaborated by the participants in the research.

The results of the evaluation of the basic fundamental knowledge highlighted the value of the means between groups for the evaluated indicators. The periodically evaluated activities, the final evaluation and the significant differences in the rounding of the final grade were taken into consideration.

The assessment made by the students regarding the didactic activity carried out by the professor proved the efficiency of teaching and evaluating the theoretical and applied perspectives in the discipline studied.

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## Conflict of interest

There is no conflict of interest to declare.

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ORIGINAL ARTICLE

# Evaluation of a body height and weight harmony among university students

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Authors' Contribution: A – Study design; B – Data collection; C – Statistical analysis; D – Manuscript Preparation; E – Funds Collection

**Abstract**

*Background and Study Aim*: A harmony between the body weight and height is one of the most important sign of the right body composition. The aim of this research was to compare objective and subjective evaluations of the body weight and height correlation by university students.

*Material and Methods*: Students of three years Bachelor programs in the humanistic university were investigated: 137 males in the age of 22.1±1.7 years old, body height – 180.0±7.9 cm, body weight – 79.6±12.3 kg; 281 females in the age of 21.5±2.1 years old, body height – 166.4±6.0 cm, body weight – 59.6±8.9 kg. During the lessons of Physical Education, students were asked to evaluate mentally their body weight value using three categories: normal, overweight, and underweight. A body weight value was evaluated using BMI model too. Correlation between results of these two evaluations was determined using the Pearson interclass correlation coefficient.

*Results*: One way ANOVA showed relatively small differences between BMI values of three studied groups: ($p=0.235$). Within groups variation was in the medium interval: from V=11.4% in the Nursing group up to 16.6% – in the Physical Education group. Totally for all the participants, Pearson interclass correlation showed moderate significant correlation ($r=0.354$, $p<0.001$) between results of the objective as BMI values and subjective evaluations as data received from a special questionnaire.

*Conclusions*: Comparison of the objective evaluation results of body weight by BMI and results of subjective evaluation regarding the body weight were compared vs. results evaluated mentally by students. Subjective evaluated results very good met results obtained from BMI values. Corresponding error appeared negligible small. Statistical hypothesis regarding a common general population these two samples was accepted.

**Keywords**: physical education, bachelor, body composition, BMI, modelling

## Introduction

A body height and a bogy weight are two most important and popular kinesiology parameters of a human body regarding Physical Education and family areas of human movements like Physical Therapy, Ergo Therapy, Para-Medical Rehabilitation, Sports, and others. A harmony between these two parameters is one of the most important sign of a right body composition. Body Mass Index (BMI) is the most popular model for determination of quality of the body composition. Because a body height is much more conservative parameter than a body weight, for determination of the optimal correlation between these parameters the second one is used usually as a function of the independent body height [1, 2].

With a purpose to improve health and general conditions, and to get a right body composition, people try to reduce a body weight to the acceptable level. Especially, this problem is an actual one for young persons, students. Last several decades, longing for "an ideal body composition" became to a standard among the university students. Father more, this aspiration for a minimal weight acquires features of a disease named Social Anorexia. For example, people who have anorexia severely reduce their food intake to lose weight [3, 4].

Although eating disorders aren't specific for age or gender, women are disproportionally affected by them. About 1 percent of all American women will develop anorexia, and 1.5 percent will develop bulimia, according to the National Association of Anorexia Nervosa and Associated Disorders. Mankind has faced the pandemic of overweight and obesity, which are factors of health and life quality deteriorating of the individuals, and the co-cause of millions premature deaths globally [5].

The frequency of overweigh and obesity occurrence is systematically rising. One of its causes is the deteriorated perception of one's body. Wrong BMI estimation causes risky eating habits, which may outcome as serious health problems. The way people perceive their body, and by how much is there perception impartial has a very big influence on their thoughts on themselves and others. Media build up fashion for one's with flawless appearance and skinny body. By promoting it mass media such as TV and internet cause among teenagers and young


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adults frustrating feeling of dissonance between their current and desirable look. It may cause many psycho and sociological problems. Uncertainty, poor self-esteem, decline in self-confidence often cause social alienation and even depression [6].

*Hypothesis of the Study*

It is reasonable to suppose that a person has his/her own intuitive model which appears in the mind based on life practice and models presented by intermediate technics, etc. So, this model is subjective one and should be evaluated using some objective criterion. BMI model is an objective method for quantitative determination of a body composition parameter. So, BMI could be used as an objective criterion for result of a subjective evaluation of a body composition. Therefore, the hypothesis of the study was formulated as follows: results of the subjective evaluation of body weight vs. body height are rather similar to results received from BMI model; an alternative hypothesis states independent results of the subjective and objective evaluations [7, 8].

*Purpose of the Study*

The research aims to compare objective and subjective evaluations of the body height and weight harmony among the university students. This goal was achieved by solving the problems as follow:

- participants' body height and body weight were measured and corresponding BMI values were calculated;
- evaluation of these body height and weight correlation was done using BMI values, i.e. the objective indicator, as well as values of the subjective indicator using results of the participants mental evaluation on the problem;
- to study a comparison of these two methods of evaluation, differences between correlation results regarding gender and speciality have been determine too.

## Material and Methods

*Participants*

Students from Nursing, Physio-Therapeutics, and Physical Education three years Bachelor programs at Technological and Humanistic University in Radom (Poland) were investigated: 137 males in the age of 22.1±1.7 years old (M±SD), body height – 180±7.9 cm, body weight – 79.6±12.3 kg; 281 females in the age of 21.5±2.1 years old, body height – 166.4±6.0 cm, body weight – 59.6±8.9 kg.

The study was approved in advance by Ethical Committee of the Technology and Humanities University named after Kasimerz Pulaski in Radom. Students participated in the research voluntarily provided written informed consent before participating. The procedures were followed in accordance with the ethical standards of the Ethical Committee on Human Experimentation [9].

*Study Design*

The research has been carried out during 2021 – 2022 Academic Year. Regarding the lessons of Physical Education, students were asked to evaluate their body weight value using three categories as results: normal, overweight, and underweight. A body weight value was evaluated using BMI value too: 18.5÷24.5 – normal, >24.5 – overweight, and <18.5 – underweight. Correlation between results of these two evaluations was determined using interclass correlation coefficient. BMI was calculated according the formula as follows [10]: BMI=(body mass)/(body weight)^2 in (kg)/(squared meters). The body weight was determined using electronic scales with an error ±*0.05* kg; the body height was determined using a floor roller with an error ±*5* mm. BMI value was calculated up to one hundredth. The participants completed the questionnaire before calculations of the BMI value, so that they did not use results of this objective evaluation during their subjective evaluation.

*Statistical Analysis*

Kolmogorov-Smirnov test with Lilliefors correction was used to check normality of distribution of the samples of age, body height, body weight, and BMI. One way ANOVA was used with a purpose to determine differences between BMI values of three studied groups. The factor of the analysis was a Bachelor program of studied university students, i.e. Nursing, Physio-therapeutics, and Physical Education. This methods as well as coefficient of variation (V=100*SD/Mean, %) were used to determine dispersions of BMI values within studied groups. Corresponding results were evaluated using the scale as follow: V=0 – 10% small variation, 11 – 20% – moderate, and over of 20% – high variation [11, p.61].

The objective evaluation results of a body weight determined using BMI and results of the subjective evaluation regarding the body weight were compared vs. results evaluated by students using the two samples paired T-test. Pearson interclass correlation was used to study correlation between results of objective (as BMI) and subjective i.e. data from the students' questionnaire. A power of the correlation was evaluated correspondingly a module of a correlation coefficient value as follow: lower than 0.2 is weak correlation, over than 0.2 and lower than 0.4 is moderate correlation, over than 0.4 and lower than 0.7 is a medium correlation, and over than 0.7 is a strong correlation [12].

Calculations have been done using Data Analysis of Excel package (One way ANOVA, Paired two samples T-test) and Statistica computer program (Kolmogorov – Smirnov test).

## Results

Because in the frames of Kolmogorov-Smirnov test with Lilliefors correction, normal distribution was revealed in all the samples (p>0.05), BMI values were elaborated using methods of parametric statistics (Table 1).

One way ANOVA showed relatively small differences between BMI values in three studied groups: 22.2÷22.9 ($p$=0.235, Table 2). Corresponding variation of data accumulated only $Q$=0.7% of the total variation. Practically all the variation was caused by the within variation in groups ($Q$=99.3%). Within group variation was in the medium interval: from V=11.4% in the Nursing group up to 16.6% – in the Physical Education group.

Totally, for all the participants, Pearson interclass correlation showed moderate significant correlation ($r$=0.354, $p$<0.001) between results of the objective (BMI values) and subjective evaluation data received from the students' questionnaire (Table 3).

Comparison of the objective evaluation results of body weight by BMI and results of subjective evaluation regarding the body weight were compared vs. results evaluated by students (Table 4). Subjective evaluated results very good met results obtained from BMI values. Corresponding error appeared 0.02 point (2.3%). Statistical hypothesis regarding a common general population these two samples was accepted using pared T-test on the convincing level of significance ($p$=0.395).

Significant and moderate correlation between these two samples was fixed as follows ($r$=0.326, $p$<0.001).

**Table 1.** Parameters of participants: males (nM=137) and females (nF=281)*

| Statistics | Age (year) | | Body height (cm) | | Body weight (kg) | | BMI | |
|---|---|---|---|---|---|---|---|---|
| | Males | Females | Males | Females | Males | Females | Males | Females |
| M | 22.1 | 21.5 | 180.0 | 166.4 | 79.6 | 59.6 | 24.5 | 21.5 |
| SD | 1.7 | 2.1 | 7.9 | 6.0 | 12.3 | 8.9 | 3.1 | 2.8 |
| Max | 29.0 | 43.1 | 204.0 | 186.0 | 125.0 | 91.0 | 38.6 | 33.8 |
| Min | 18.0 | 19.0 | 154.0 | 150.0 | 55.0 | 43.0 | 16.5 | 16.6 |
| D | 0.131 | 0.163 | 0.085 | 0.075 | 0.101 | 0.085 | 0.106 | 0.147 |

*Notes: nM and nF are male and female participants' numbers correspondingly, M is arithmetic mean value, SD is standard deviation, D is Kolmogorov – Smirnov statistics, p is significance, p(D)>0.05.

**Table 2.** Results of ANOVA of BMI values

| Source of dispersion | SS* | df | MS | F | p | F(0.05, 2, 415) | Q, % |
|---|---|---|---|---|---|---|---|
| Between groups | 30.4 | 2 | 15.2 | 1.453 | 0.235 | 0.051 | 0.7 |
| Within groups | 4346.4 | 415 | 10.5 | | | | 99.3 |
| Total | 4376.8 | 417 | 10.5 | | | | 100.0 |

*Note: SS is sum of squars, df is degree of freedem, MS – mean squars (variance), F is Fisher statistics, Q is a part of the total dispersion, p is significans.

**Table 3.** Results of the subjective evaluation of body weight (from questionnaire) vs. BMI values

| Statistics* | Group | | | |
|---|---|---|---|---|
| | Nursing | Physio-therapeutics | Physical Education | Total |
| n | 140 | 184 | 94 | 418 |
| M | 22.2 | 22.6 | 22.9 | 22.5 |
| SD | 3.7 | 3.2 | 2.6 | 3.2 |
| V(%) | 16.6 | 14.1 | 11.4 | 14.4 |
| r | 0.377 | 0.451 | 0.164 | 0.354 |
| t | 4.784 | 6.861 | 1.590 | 7.727 |
| p(r) | <0.001 | <0.001 | 0.058 | <0.001 |

*Notes: n is participants' number, M is arithmetic mean value, SD is standard deviation, V is coefficient of variation, r is Pearson correlation coefficient, t is Student statistics, p(r) is significance.

**Table 4.** Comparison of the objective evaluation results of body weight by BMI and subjective evaluation results by questionnaire

| Statistics* | Types of evaluation | |
|---|---|---|
| | Objective (using BMI) | Subjective (questionnaire) |
| n | 418 | 418 |
| M | 1.15 | 1.17 |
| SD | 0.53 | 0.56 |
| r, p(r) | 0.326, <0.001 | |
| D, p(D) | 0.02, 0.395 | |

*Notes: n is participants' number, M is arithmetic mean value, SD is standard deviation, r is Pearson correlation coefficient, D is difference of means, p(D) and p(r) are significances.

## Discussion

According to the purpose of the research, correlation results of the objective and subjective evaluations of body height and weight by university students have been compared. Hypothesis of the study about significant right correlation between results of the objective and subjective has been acceptes ($r$=0.354, $p$<0.001), but the problem of over weight is rather familiar to the theme of this research.

The closer the appearance is to the ideal promoted in the mass media (lower body mass and BMI), the more the chance for a proper self-esteem of one's body increases. This is confirmed by the observations from the surveys and anthropometric measurements of female students of Gdansk University of Physical Education and Sport (N = 1394) from 2003-2010, among whom 70.23% of students made a correct BMI self-assessment, 26.76% overestimated the results, and only 3.01 % underestimated values. In this study, attention is drawn to the fact that in the group of respondents who incorrectly recorded their BMI, 91.18% are female students practicing sports [6].

Social patterns of sex shape the perception of their own body also by students. This is confirmed by the research of Wright et al., which found that male and female students underestimated body weight and overestimated height at an average level, which led to more favourable BMI results [13, 14]. Additionally, it was shown that men had a stronger tendency to overestimate their height, while women mainly underestimated their weight. Similar conclusions were reached by Wilson et al. and Radwan et al. [15, 16].

Overweigh people are often perceived stereotypically as awkward, unattractive and lazy, whereas the slim one's enjoy public approval and recognition. It is commonly believed that they are attractive and happy, and that they can easily establish professional and social connections. Additionally, it should be feared that the rising factors of overweight and obesity in contemporary population may normalize heavier body as a reference, making it more difficult to diagnose themselves right. The overweight and obese will stop perceiving their appearance as a risk factor over time and will start to ignore messages about healthy lifestyle [17, 18].

The somatic development study of successive generations allows us to observe varied influences of social, economic and urban changes on melding of morphological traits of the population. Crucial is to consider relation of two basic factors of physical development that is height and body mass. On the one hand, we can observe the acceleration of human development, which manifests itself in a greater body height of successive generations, but on the other, we see dangerous for health development of overweightness and obesity [19, 20, 21].

Studies on somatic development of the population are generally based on survey data. The respondents state in the questionnaire their height and body mass, what allows us to count the Body Mass Index (BMI) and estimate fast weather the respondent is underweight – in a correct value – overweight. Sadly, the self-description is often not objective. The inconsistencies of self-descriptions are caused by underestimations of body mass, overestimating the height or both. The literature review shows that women mostly underestimate body mass, what can be caused by a will of perceptual adjustment to cultural ideal promoted by media, whereas man overestimate their height and weight to emphasize the need of being big and muscular [22, 23].

Among people who underestimate their weight beside women studies indicate heavier people of both sexes, whereas the height is commonly overestimated by smaller man and elder people of both sexes. Beside sex and age mistakes in estimations (although in a smaller range) can be the result of education, marital status, and even race It seems that the growing awareness considering healthy lifestyle induce people to state anthropometric values, which in fact are they dream values. If the results of the study are being unreliable it affects unfavourably public health monitoring, especially in high-risk populations [24, 25].

Relatively fewer studies have been conducted on the differences between objective and reported height, body weight and BMI values among students. They were the subject of national and international research mainly due to the psychological and social instability accompanying this age group and the specificity of functioning in the university environment [26, 27].

It is motivating that the same awareness regarding healthy lifestyle patterns encourages people to take beneficial pro-health activities. The growing interest in health is indicated by the fitness industry, which has been dynamically developing since the end of the last century, with has currently around 185 million members worldwide (with an increase of 54% over the last decade). Exercising in fitness clubs is often promoted as a fat loss strategy - which is very encouraging, attractive and socially necessary [28].

A review of the literature generally shows large variations in body image dissatisfaction among students of ranging from 5% to 87%. This both sexes, dissatisfaction resulted from students' contacts with social and normal media, and were associated with low self-esteem, more often related to the female gender. Relatively fewer studies have been conducted on the differences between objective and reported height, body weight and BMI values among students. They were the subject of national and international research mainly due to the psychological and social instability accompanying this age group and the specificity of functioning in the university environment [29].

The research on the level of body image dissatisfaction among students of specific faculties is very inspiring. It seems especially important to monitor dissatisfaction and disturbed body perception among students who will be professionals responsible for the promotion and enhancement of public health in the future. This applies, for example, to students of physical education, nursing, physiotherapy, medicine [30].

As the presented research results show, the BMI assessment cannot be based solely on information obtained from self-assessment, because even athletes with perfect bodies make mistakes in this regard. In each case, a self-esteem that deviates from reality may result in, improper food choices and have serious health consequences. It is extremely important that future specialists responsible for the promotion and enhancement of public health (today's students of nursing, physical education, physiotherapy and medicine) were able to reliably examine and assess the level of their somatic development and how to take best care of their health. During their studies, they should be equipped with knowledge and practical skills in this field. This will guarantee the effectiveness of their work in the field of public health [31, 32].

It is extremely important that future specialists responsible for the promotion and enhancement of public health (today's students of nursing, physical education, physiotherapy and medicine) were able to reliably examine and assess the level of their somatic development and how to take best care of their health. During their studies, they should be equipped with knowledge and practical skills in this field. This will guarantee the effectiveness of their work in the field of public health [33].

## Conclusions

Comparison of the objective evaluation results of body weight by BMI and results of subjective evaluation regarding the body weight were compared vs. results evaluated by students. Subjective evaluated results very good met results obtained from BMI values. Corresponding error appeared negligible small. Statistical hypothesis regarding a common general population these two samples was accepted using pared T-test on the convincing level of significance.

*Highlights*

There were discovered the normal distribution of a body height and a body weight values in students of all the three specialities i.e. Nursing, Physio-therapeutics, and Physical Education ($p>0.05$) that made possible to apply methods of parametric statistics in elaboration of results of measurements and questioning.

BMI values of students in the Physical Education students appeared greater ($22.9\pm2.6$) than corresponding values in the Nursing ($22.2\pm3.7$) and in the Physio-therapeutics students ($22.6\pm3.2$). However, these differences were not significant.

The interclass correlation between results of subjective and objective evaluation in the group of the Physical Education students appeared rather weaker ($r=0.164$, $p=0.058$) comparatively with two others groups ($r=0.337\div0.451$, $p<0.001$).

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## Conflict of interest

The authors declare no conflict of interest.

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