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**Examination of the doctoral thesis of Athanasios Mandroukas, MSc. entitled  
„Physiological and neuromuscular changes between young soccer players and untrained  
young subjects. A comparison study“**

The candidate presents a study that sought to investigate the changes in maximal oxygen uptake, isokinetic muscle strength and anthropometric characteristics in soccer players and untrained adolescents of different ages. The results showed that systematic soccer training has a positive effect on the cardiorespiratory system expressed as  $VO_{2max}$ , heart rate and blood pressure, as well as neuromuscular functions in terms of increased strength of lower limbs.

This topic is interesting and it may contribute to the current state of knowledge by getting objective insight into the effectiveness of training programs in young soccer players. A better understanding of the physiological and neuromuscular changes during systematic training may enable exercise professionals to design smart exercise regimens specifically tailored for young soccer players. Focusing training programs in such an efficient and highly effective manner could contribute to the enhancement of performance in soccer.

The review of the literature is comprehensive with relevant papers in the field of the doctoral thesis. However, I would expect more up-to-date papers associated with the topic of the thesis, what's the effects of soccer-specific training on physiological and neuromuscular variables in young players aged 12 to 16 years. I would omit the chapters "2.2 Anthropometric characteristics", which is primarily related to the anthropometric measurements (page 8), and "2.3.4 Familiarisation of strength measurements" (pages 13-14).

The candidate accurately stated the problem being investigated. A scope of the doctoral thesis was to compare selected anthropometric, physiological and neuromuscular variables between young soccer players and untrained adolescents of three age categories (12, 14, and 16 years). Nevertheless, it is not sufficiently explained why exactly these characteristics of young soccer players were selected (e.g., measurement of isokinetic muscle strength of knee extensors and knee flexors instead of assessment of muscle strength and power during dynamic movements or speed and agility skills). “As noted earlier, soccer is a complicated sport involving a myriad set of activities such as jumps, feints and directional speed changes. The events put pressure on the lower limbs, showing the need for the development of muscle strength in soccer players.” (page 59). Besides this, I would suggest not to include the examination of anthropometric characteristics such as weight, height, body surface area, lean body mass, and body mass index in the purpose of the study.

The hypotheses as they stands do not concisely focus on aspects that would argue in favor of the novelty and the high relevance of this research (page 21):

Ha: Young soccer players will have higher absolute and relative muscle strength than untrained young subjects;

Ha: The strength ratio of H:Q will be higher in young soccer players, in comparison with the young untrained subjects of the same age;

Ha: PT values of knee extensors and knee flexors will significantly increase with age, whereas the ratio of H:Q will be different among ages;

Ha:  $\dot{V}O_2\text{max}$  will be different between young soccer players and untrained healthy adolescents of the same age.

Experimental design is appropriate. There are, however, minor concerns related to the methodology which have not been addressed.

The sampling seems to be sufficient. However, there is no information whether a priori power analysis for estimating appropriate sample size was provided. The inclusion criteria for subjects to be allocated to the study are not sufficiently specified: “The untrained group participated only in their normal Physical Education program in their school and did not take part in any other sport activities. The trained group participated both in their schools Physical Education program and in the national championship competition games. They were a highly selective group with regard to skills, performance, size, anthropometric characteristics and physical condition.” (page 23). Also, the intensity of exercises in soccer players and age-matched control groups should be more precisely specified: “Both the

duration and the intensity of the training in this group were much less than the specific training program of the soccer players.” (page 24).

The candidate accurately explained how the data were collected. Protocols of 3.2.1 Anthropometric measurements (page 25), 3.2.2 Blood Pressure (pages 25-26), 3.2.3 Isokinetic Strength Testing (pages 26-27), and 3.2.4 Determination of maximum oxygen uptake (pages 27-28) were adequately described. I appreciate clearly described procedures. Sufficient information was presented to replicate the research.

In the light of the research tasks, statistical methods are adequate. However, it is not reported whether the test for normality and the test for equality of error variances were performed. In addition, primary and secondary outcome variables are not clearly defined.

Findings are presented in a clear concise way. I appreciate the effort of the candidate for detailed presentation of results, however some parts in this chapter fails to present the main findings in an appropriate way. For instance, “the physical and anthropometric characteristics between trained and untrained adolescents in different age groups” (pages 30-35) should be included in 'Material' section. It was not necessary to duplicate data included in Table 1 also in Figures 1-5. Similarly, the data in Table 2 are the same like those included in subsequent figures (pages 35-42). Moreover, figures present a comparison of values between trained and untrained subjects in different ages, whereas a comparison of values in three age categories separately in a trained and an untrained group is described. For instance, “For the trained group there were no significant differences between the 12 and 14 years old trained adolescents as well as between the 14 and 16 trained. The only significant difference for that group were found between the 12 and 16 years old trained boys (Figure 6)” (page 37). Sometimes non-uniform terminology and small mistakes in the text (e.g., not correct identification of Figures 11, 13, 15 on page 43) makes a thesis readability more complicated.

In this chapter, at least two questions deserve to be addressed:

1. Please, explain no significant differences in peak torque of knee extensors and knee flexors at angular velocities of 60, 180 and  $300^{\circ}\cdot s^{-1}$  between 14 years old trained and untrained adolescents (pages 43-46);
2. Please, explain no significant differences in peak torque of knee extensors and knee flexors at angular velocities of 60, 180 and  $300^{\circ}\cdot s^{-1}$  between 12 and 14 years old soccer players (Figures 14-16).

The discussion reflects what the candidate found and how it relates to the literature. The candidate incorporated previous research into the interpretation of the results. He demonstrated an appropriate understanding of previous research on the topic and included

related references. The claims in this chapter are reasonable and supported by the results. The candidate clearly indicates how the findings relate to expectations and hypotheses. The contribution of this thesis in comparison with earlier research is explained. Its limitations are also included. However, the candidate does not sufficiently present the practical applications of obtained findings with respect to young soccer players that are not currently addressed in the literature.

The conclusion should be briefly presented in a more systematic and structured way. It is mainly focused on testing methods used, whereas does not present any conclusions built upon the findings. I cannot agree with the following statement due to a relatively small sample size. "The results of the present study can be used as normative data for young soccer players, as well as for the general population of young boys, throughout the developmental ages (12, 14, 16) with regards to the cardiorespiratory system and to the H and Q muscle strength." (page 68). Further studies are needed to provide a normative data on measures used in the present thesis.

This thesis adds novel but not significant data to the existing knowledge. The summary includes the most important findings, as follows: "The trained group showed significantly higher  $\dot{V}O_{2max}$ , in absolute and relative values ( $p < 0.001$ ),  $BL_{max}$  ( $p < 0.05$ ) and  $RER_{max}$  ( $p < 0.05$ ) compared to the untrained group. Resting HR and systolic blood pressure were significantly lower ( $p < 0.05$ ) for the trained compared to untrained. The isokinetic muscle strength (absolute and relative) was significantly higher ( $p < 0.001$ ) in the 12 and 16 years old trained group, compared to untrained, for the knee extensors and knee flexors. However, no significant differences were found between the 14 years old trained and untrained, for the muscle groups of Q and H. The H:Q strength ratios did not differ between groups at all angular velocities." (pages iv-v).

In general, the doctoral dissertation is well structured with proper balance between the chapters. In the literature review, the candidate refers many relevant papers related to the topic of the thesis. Based on this analysis, he clearly stated the purpose of the study. Accordingly, the appropriate hypotheses were set up. The experimental design, subjects and methods selection reflect particular tasks and correspond with scientific principles. Such design is suitable for answering the question posed. The results of this research are of relevance to the field of exercise science and their interpretation is in accordance with common scientific standards.

In my opinion, this thesis demonstrates that the candidate can conduct independent scientific research. The dissertation forms well an integrated scholarly whole. The candidate

has sufficiently proven his capability to identify scientific problem, analyze relevant literature, select appropriate methods, design scientific experiments, collect and process data, present and discuss results and formulate conclusions. Even after rigorous review, only small critical remarks and comments were made.

I do recommend that the doctoral dissertation of Athanasios Mandroukas, MSc. entitled „Physiological and neuromuscular changes between young soccer players and untrained young subjects. A comparison study“ will be approved.

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