

The effects of swimming training on selected strength and respiratory function variables in pre-pubertal children**Hayriye Çakır Atabek¹****Received: 28.02.2017****Accepted: 30.05.2017****Abstract**

Objectives: The purpose of this study was to examine the effects of swimming training on selected strength and respiratory function variables in pre-pubertal children.

Methods: Thirteen trained 7- to 10-years-old swimmers who were the members of the same college team and who trained for at least 6 months, 3 days a week volunteered to participate in this study. The values of investigated variables were compared with the values of the untrained group, matched for age and gender. Forced vital capacity (FVC), forced expiratory volume in one second (FEV1), and maximum voluntary ventilation (MVV) were measured to determine the respiratory function. The bio-motoric properties were evaluated by right and left handgrip isometric strength, and vertical jumping height, determined by squat jump (SJ) and counter movement jump (CMJ) tests.

Results: Mean age, height, weight and BMI values were not significant different between groups ($p > 0.05$). The respiratory function (FVC, FEV1 and MVV values) and handgrip-right and handgrip-left values were not significant different between groups ($p > 0.05$). Additionally, SJ values were not different between groups ($p > 0.05$), but CMJ values were significantly different between groups with higher values in trained group ($p = 0.012$).

Conclusion: There are studies that put forth the positive effects of exercise programs on the respiratory functions of individuals who have not yet completed their developments as well as studies that state the contrary. The findings of the current study demonstrated that

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there was a statistically significant difference only for CMJ performance in favor of trained children, and not for the other investigated variables. Inadequate training experience and little age of the participants may explain the results. It has been determined that the respiratory functions are closely related to body size which increases with chronological age and training factors may not affect the lung capacity.

Keywords: Respiratory function, Handgrip strength, Jumping height, Pre-pubertal children,

INTRODUCTION

Sport is useful and necessary in terms of physical, physiological and personality development of children in the age of growth. Participating in regular sports activities before and after adolescence ensures healthy circulation and respiratory system, and at the same time, it contributes to the mental and spiritual development (Alpay et al., 2007). Children regulate social relationships through sports; they improve self-confidence, competitiveness, motivation and control. Swimming is one of the most practiced sports in western countries, where sedentarism and obesity are increasing, especially in children (Font-Ribera et al., 2011). Evidence shows that water exercises and swimming increase lung function, and aerobic capacity, improve cardiovascular fitness and quality of life (Weisel et al., 2009).

Strength is important component related to daily life. Physical educators use strength testing to evaluate student performance. In addition, coaches use strength testing to monitor effectiveness of training and to select athletes for sports team. Researchers use strength testing to identify both the determinants and trainability of strength during childhood (Almuzaini, 2007). Grip strength is often used in evaluating physical fitness status as an indicator of overall physical strength (Massey-Westrop et al., 2004; Koley et al, 2011), because, a typical hand dynamometer is simple, not expensive, and well established method for assessing the

strength (Gerodimos, 2012). It has also been shown that handgrip strength is associated with maximum upper and lower body strength values (Milliken et al., 2008, Cohen et al., 2010). Additionally, jumping tests are used to indirectly measure the strength/power property of lower-body and for this, the jump height is utilized.

Within our knowledge, there is limited number of studies with conflicting results that examined the effects of training on strength and respiratory function development in pre-pubertal children. However, the participation of children in organized sports program has increased recently. Hence, the purpose of the current study was to investigate the effects of swimming training on handgrip strength, jumping performance and pulmonary function in pre-pubertal children.

METHODS

Participants: Thirteen trained and thirteen untrained 7- to 10-years-old children volunteered to participate in this study. Thirteen trained swimmers (n = 8 male and n = 5 female) were members of the same college team who had trained for at least 6 months, 3 days a week. Investigated variables of the swimmers were compared with untrained children from the same college (n = 8 male and n = 5 female), matched for age and gender. Lack of information about whether the untrained children had participated regularly in physical activity different from swimming is one of the limitation of the current study. None of the participants had medical history, leg or arm injury, cardiovascular and pulmonary diseases. At the beginning of the study all participants and their parents were informed about possible risks and benefits of the study and written consent forms were obtained from parents. The study was conducted in accordance with the Declaration of Helsinki, and approved by the Institutional Review Board (Protocol number: 19984).

Anthropometric measurements: Subjects' height was measured using a stadiometer (Holtain, Britain) and subjects' weight was determined by bioelectrical impedance (BIA) analyzer (Tanita TBF 401A, Japan). The body mass index (BMI) was calculated (Formula 1).

$$\text{BMI} = \text{Weight (kg)} / \text{Height}^2 \text{ (m)} \qquad \text{Formula 1}$$

Isometric handgrip strength: Each participant was given a brief demonstration and verbal instructions for the handgrip test using the Takei T.K.K.5101 digital handgrip dynamometer (Takei Scientific Instruments Co. Ltd, Tokyo, Japan). If necessary, the grip opening was adjusted according to the subject's hand size. The test was conducted for both the dominant and non-dominant hand, in standing, with shoulder adducted and neutrally rotated, the wrist, and the elbow in full extension. The dynamometer was held freely without support, not touching the subject's trunk (Koley et al., 2011). Three trials were allowed with sufficient recovery period and the highest score was recorded in kilograms (kg) as peak grip strength.

Jump tests: Following a standardized warm-up of 5-7 minute of jogging and 5-7 minute of dynamic stretching in indoor saloon, the participants rested for 5-min. All jumps were performed using a dedicated force platform (Sport Expert TM, MPS-501, Tümer Electronic LDT, Turkey). After a familiarization session each subject performed three maximal voluntary vertical jumps at each of two testing conditions - Squat Jump (SJ) and Counter Movement Jump (CMJ); and the best value of the three trials were used for further analyses. The SJ was performed from a starting position with the subjects' knees flexed to 90°, hands fixed on the hips and with no allowance for preparatory counter-movement. The CMJ was performed from an upright standing position, with the hands fixed on the hips and with a counter movement; preparatory phase ended at a position corresponded to the starting position in SJ. More than 2 minutes was given for rest among trials.

Pulmonary Functions: A Spiro lab III ergo spirometer (Medical International Research, Italy) was used to measure pulmonary functions. The spirometric values were measured when the subjects were in seated position (Kürkçü & Gökhan, 2011; Alpay et al., 2007). Wearing a nose clip, and following a maximal inspiration, subjects performed a maximal expiration for the determination of forced vital capacity (FVC), forced expiratory volume in one second (FEV1), and maximum voluntary ventilation (MVV).

Statistical analyses: The analyses were executed using the SPSS for windows (version 18.0). Descriptive statistics were computed for each group and all values were presented as mean \pm standard deviation (SD). The normality of distribution of the data was assessed with Shapiro – Wilk test; the physical properties were compared between groups using the "Mann Whitney U" test, additionally, the pulmonary function (FVC, FEV1, and MVV), and performance values (handgrip strength, SJ, and CMJ) were compared between groups using the "independent student t-test". The statistical significance was set at $p < 0.05$. The achieved power ($1-\beta$) for a sample size of 13 participants (for each group) was computed at an α level of 0.05 (2-tailed) using the G*Power (version 3.1.9.2), and the values were reported for significant findings.

RESULTS

The physical properties of the trained and untrained participants are presented in Table 1. Mean age, height, weight and BMI values were not significant different between groups ($p > 0.05$). The pulmonary function values are presented in Table 2, additionally, handgrip strength, SJ and CMJ performance test values of the participants are presented in Table 3. The FVC, FEV1 and MVV values were not significant different between groups ($p > 0.05$). The results indicated that the handgrip-right (handgrip-R) and handgrip-left (handgrip-L) values were not significant different between groups ($p > 0.05$). Additionally, SJ values were not

different between groups ($p > 0.05$), but CMJ values were significantly different between groups with higher values in trained group ($p = 0.012$; $1-\beta = 0.95$).

Table 1. The physical properties of the trained and untrained participants

Variables	Groups	Mean \pm SD	Min value	Max value
Age (years)	Trained	8.07 \pm 1.11	7.00	10.00
	Untrained	8.07 \pm 1.11	7.00	10.00
Height (cm)	Trained	128.11 \pm 9.02	118.80	148.00
	Untrained	126.37 \pm 9.44	114.00	144.00
Weight (kg)	Trained	25.78 \pm 6.64	16.90	41.80
	Untrained	28.10 \pm 10.46	19.30	54.50
BMI (kg/m ²)	Trained	16.07 \pm 2.16	13.70	21.30
	Untrained	17.10 \pm 3.79	13.50	26.30

BMI = body mass index.

Table 2. The pulmonary function values of the trained and untrained participants

Variables	Groups	Mean \pm SD	Min value	Max value
FVC (L)	Trained	1.81 \pm 0.46	1.08	2.77
	Untrained	1.56 \pm 0.46	0.81	2.48
FEV1 (L)	Trained	1.41 \pm 0.35	0.99	2.06
	Untrained	1.22 \pm 0.39	0.61	1.99
MVV (L/m)	Trained	51.61 \pm 13.95	25.50	76.00
	Untrained	40.04 \pm 21.19	18.50	100.60

FVC = forced vital capacity; FEV1 = forced expiratory volume in one second; MVV = maximum voluntary ventilation.

Table 3. Handgrip strength, SJ and CMJ performance values of the trained and untrained participants

Variables	Groups	Mean ± SD	Min value	Max value
Handgrip-R (kg)	Trained	12.67 ± 2.64	8.10	16.80
	Untrained	11.43 ± 3.20	6.20	17.80
Handgrip-L (kg)	Trained	12.22 ± 2.61	7.40	15.40
	Untrained	10.89 ± 2.90	5.90	16.80
SJ (cm)	Trained	13.00 ± 2.67	9.00	17.00
	Untrained	11.15 ± 2.73	8.00	17.00
CMJ (cm)	Trained	15.76 ± 2.80*	11.00	19.00
	Untrained	12.69 ± 2.95	9.00	19.00

Handgrip-R = handgrip right strength; Handgrip-L = handgrip left strength; SJ = squat jump; CMJ = counter movement jump. *p<0.05 significantly different from untrained group value.

DISCUSSION

Respiratory system functions are affected from body size, and this is closely related to age. For this reason, the current study was conducted on the same age group of children. The findings demonstrated that the respiratory function (FVC, FEV1, and MVV values) and handgrip-R and handgrip-L values were not significant different between groups ($p > 0.05$). Additionally, SJ values were not different between groups ($p > 0.05$), but CMJ values were significantly different between groups with higher values in trained group ($p = 0.012$).

It is well known that the level of physical activity affect the lung volumes (Andersen et al., 1980). It has been reported that the VC, and FVC values of basketball players (mean age 12.6 years) were significantly higher than untrained boys at the similar age (Alpay et al., 2007). Similarly, the FVC and FEV1 values of handball players were significantly higher than

the values of control group [2.62 and 2.88 vs 1.89 and 1.83, respectively] (Kürkçü & Gökhan, 2011). İmamoğlu and Kılıcıgil (2007) reported that the values of vital capacity in 10-13 years old football players were 1.64 (lt), 2.04 (lt), 2.30 (lt), and 2.50 (lt) respectively. Differently from the mentioned studies above, the VC, FVC, and FEV1 values in 11-year old football players were recorded as 2.03 ± 0.62 , 1.99 ± 0.59 , and 1.95 ± 0.55 versus 1.93 ± 0.33 , 1.71 ± 0.31 , and 1.72 ± 0.34 respectively in 11-year old badminton players, and no significant difference was observed between groups for investigated variables (Kürkçü et al., 2009).

Dağlıoğlu et al. (2006) showed that the VC values of 7-13 year old children increased from 1.74 ± 1.13 (lt) to 2.42 ± 1.12 (lt) after participating to the swimming summer training program. Furthermore, it has been demonstrated that the VC, FVC, and FEV1 values significantly increased in 8-12 year old children after 3-month training (Kesavachandran et al., 2001). Eriksson et al (1978) have also noted that increased lung volume was already present in a group of 10 year old boys (n = 18) who had just begun swimming training. Additionally, one-year of intensive endurance swim training was shown to induced significant increase in static and dynamic lung volumes, and in particular, an improvement of the flow-volume relationship in pre-pubertal girl swimmers (mean age 9.8 years) in comparison with children who had a normal level of physical activity (Courteix et al., 1997).

The study conducted by Andersen et al. (1980) reported the FVC and FEV1 values in 8-year old boys as 2.10 ± 0.29 , and 1.82 ± 0.25 , and in 8-year old girls as 1.88 ± 0.25 , and 1.72 ± 0.23 , respectively. These values are higher than the values reported in the current study. The physical fitness status of children involved to the mentioned study may explain this situation; the VO_2 max value was reported as 53.8 ± 3.70 (mL.min⁻¹.kg⁻¹) for boys and 49.4 ± 7.08 (mL.min⁻¹.kg⁻¹) for girls (Andersen et al., 1980). When the Turkish population is considered, the VO_2 max values have been recorded as 27 mL.kg⁻¹.dk⁻¹ in 10-11 year old girls

(Saygın et al., 2011; Saygın & Dükancı, 2009), and $32 - 33 \text{ mL.kg}^{-1}.\text{dk}^{-1}$ in 10-11 year old boys (Saygın et al., 2011; Saygın et al., 2009). The VO_2 max value has been determined as $35.12 \pm 4.9 \text{ mL.kg}^{-1}.\text{dk}^{-1}$ after 12 week-movement training in the girl athletes (mean age: 10.4 ± 0.7 years) (Ölçücü et al., 2011). In another study, the VO_2 max value has been observed as $39.76 \pm 8.6 \text{ mL.kg}^{-1}.\text{dk}^{-1}$ after 16 week- movement training program in boy athletes (mean age: 11.1 ± 0.8 years) (Saygın et al., 2005). In the current study, since we did not measure the VO_2 max, it is difficult to compare these findings.

It has been suggested that respiratory muscles can increase their strength and endurance capacity in response to specific training (Courteix et al., 1997). Swimmers perform strenuous underwater exercise holding their breath for prolonged periods (Bougault et al., 2009). Hence, respiratory muscles, including swimmer's diaphragm, are required to develop higher pressure, resulting from water immersion during respiratory cycle, leading to functional strengthening of the muscles, as well as improvement in the chest wall elasticity, resulting in higher level of the lung function (Bougault et al., 2009; Lazovic-Popovic et al., 2016).

Regarding spirometric parameters, one possible limiting factor in our study was the fact that children were still in the early stages of the swimming program. Training experience and training frequency may explain this situation. In the current study, children were subjected to the swimming training for 6 months and it seems that this period was not enough for significant alteration in respiratory function. Longitudinal studies of subjects involved in land based activities (i.e. athletics, basketball, canoeing, and rowing) show lung volume to be unaffected by short term training (Doherty & Dimitriou, 1997). Furthermore, other studies were also unable to detect lung volume increases in child swimmers after six or seven months of training (Gibbons et al., 1972; Vaccaro et al., 1978). On the other hand, and in consistent

with the findings of the current study, Özgül et al. (2015) showed that the FVC and FEV1 values did not change significantly in boys and girls athletes (mean age 12.0 ± 1.3 and 11.8 ± 1.2 years, respectively) after 8-week swimming training program [FVC values: 1.84 ± 0.42 vs. 1.88 ± 0.41 ; FEV1 values: 1.74 ± 0.41 vs. 1.82 ± 0.41).

Lazovic-Popovic et al. (2016) compared pulmonary parameters between swimmers, footballers and age- and sex-matched controls, and reported that the swimmers had significantly higher FVC and FEV1 values. Additionally, this research group investigated the influence of training factors (*training period (years), age at the beginning of training (years), and weekly amount of training (hours)*) on the pulmonary function indices in swimmers (*controlled for anthropometric features*) and reported that there was no influence of any of the training factors on the percentage of the predicted FVC and FEV1 values. On the other hand, it has been determined that there was a significant positive correlation between age, body weight, body height, and spirometric variables (Lazovic-Popovic et al., 2016). Silvestri et al. (2013) also have reported similar findings. As a result, the age of participants (mean age: 8 ± 1 years) seems to be more reasonable affect and explanation for the current findings regarding the spirometric parameters.

There are many important factors in the objective evaluation of strength in the pediatric population and the handgrip strength test is one of the most common methods of measuring isometric strength in children (Van Praagh & Franca, 1998). España-Romero et al. (2010) found high reliability of handgrip strength in both children and adolescent using the Takei hand dynamometer. Other studies also support this finding in both pre-pubertal and pubertal children (Gerodimos, 2012; Molenaar et al., 2008).

Handgrip strength is a physiological variable that is affected by a number of factors including age, gender, and body size (Koley et al., 2011). In a study conducted by Şahin et al.

(2011) the handgrip strength of right and left hand was reported as 5.33 ± 1.29 and 5.27 ± 2.28 in 7-year-old taekwondo athletes. Additionally, in the mentioned study the handgrip strength of right and left hand was reported as 8.13 ± 1.31 and 7.97 ± 2.29 in 8-year-old athletes. It has been observed that the handgrip strength values were significantly different between groups ($p < 0.01$) (Şahin et al., 2011). Another study demonstrated that isometric handgrip strength in 11-to 13-year-old children was 17.0 ± 2.3 (kg) (Almuzaini, 2007). Kafkas et al. (2009) indicated that 11-year-old elite badminton players had significantly higher handgrip strength values (18.43 ± 4.16 kg) than amateur players (13.97 ± 1.05 kg). In contrast to this study, although, the handgrip strength values recorded in the current study are higher than the values recorded for 7-to 8-year-old taekwondo athletes, there was no significant differences between groups.

SJ and CMJ are commonly used tests to measure athlete-jumping ability. SJ is used to measure the lower-body concentric strength/power, while CMJ is used to measure the lower-body reactive strength/power (Newton et al., 2006). The SJ can be used as the most basic functional expression of explosive muscle strength as it requires only concentric activation. The CMJ requires moderate eccentric activation followed by high concentric activation, and therefore requires a more complex timing and graduation of the motor units. Thus the SJ can serve as a baseline for the potential of explosive muscle strength and CMJ may indicate development of this potential (Bencke et al., 2002). Almuzaini (2007) demonstrated that vertical jump height in 11-to 13-year-old children was 32.2 ± 4.0 (cm). Another study reported the jumping height values in 7 and 8 year-old athletes as 19.20 ± 3.92 and 29.40 ± 3.94 , respectively and significant difference between groups ($p < 0.01$) (Şahin et al., 2011). Comparing with the mentioned study, the results of the current study are quite low.

Significant difference in CMJ values show that the elastic strength can be developed by training in children of this age group.

CONCLUSION

Consequently, the main finding of the current study show that the six-month swimming training did not affect the respiratory function in 7- to10-year-old children. One possible explanation for these findings may be the inadequate training experience, which have might result in insufficient adaptation. The other more reasonable explanation may be the little age of the participants. It has been reported that the respiratory function increases with chronological age and training factors may not affect the lung capacity. It should be pointed out that the mean values of spirometric variables are higher for swimmers; the small sample size of the groups may have affected the results, so that performing the study in larger sample groups is recommended. Even it is known that the jumping height increases with age, the results show that the swimming training can improve the elastic strength in pre-pubertal children.

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References

- Almuzaini, K.S. (2007). Muscle function in Saudi children and adolescents: Relationship to anthropometric characteristics during growth. *Pediatr Exerc Sci*, 19(3), 319-333.
- Alpay, B., Altuğ, K., & Hazar, S. (2007). Assessment of some respiratory and circulation parameters of 11-13 age group students in primary school teams by comparing them with untrained students. *Mehmet Akif Ersoy University Journal of Education Faculty*, 8, 22-29.

- Andersen, K.L., Seliger, V., Rutenfranz, J., & Nasset, T. (1980). Physical performance capacity of children in Norway. V. The influence of social isolation on the rate of growth in body size and composition and on the achievement in lung function and maximal aerobic power of children in a rural community. *Eur J Appl Physiol Occup Physiol*, 45(2-3), 155-166.
- Bencke, J., Damsgaard, R., Saekmose, A., Jorgensen, P., Jorgensen, K., & Klausen, K. (2002). Anaerobic power and muscle strength characteristics of 11 years old elite and non-elite boys and girls from gymnastics, team handball, tennis and swimming. *Scand J Med Sci Sports*, 12(3), 171–178.
- Bougault, V., Turmel, J., Levesque, B., & Boulet, L.P. (2009) The respiratory health of swimmers. *Sports Med*. 39(4): 295-312. doi: 10.2165/00007256-200939040-00003.
- Cohen, D.D., Voss, C., Taylor, M.J., Stasinopoulos, D.M., Delextrat, A., & Sandercock, G.R. (2010). Handgrip strength in English schoolchildren. *Acta Paediatr*, 99(7), 1065-1072.
- Courteix, D., Obert, P., Lecoq, A.M., Guenon, P., & Koch, G. (1997). Effect of intensive swimming training on lung volumes, airway resistance and on the maximal expiratory flow-volume relationship in prepubertal girls. *Eur J Appl Physiol Occup Physiol*, 76(3), 264-269.
- Dağlıoğlu, Ö., Çınar, V., Bostancı, Ö., Dağlıoğlu, T., & Hazar, M. (2006). Evaluation of respiratory parameters of children attending summer sports school swimming program. 9th International Sport Sciences Congress abstract book, 459-461
- Doherty, M., & Dimitriou, L. (1997). Comparison of lung volume in Greek swimmers, land based athletes, and sedentary controls using allometric scaling. *Br J Sports Med*, 31(4), 337-341.

- Eriksson, B.O., Engstrom, I., Karlberg, P., Lundin, A., Saltin, B., & Thoren, C. (1978). Long-term effect of previous swimming training in girls: a 10-year follow-up of the "girl swimmers". *Acta Paediatr Scandinavica*, 67(3), 285-292.
- España-Romero, V., Artero, E.G., Jimenez-Pavón, D., Cuenca-Garcia, M., Ortega, F.B., Castro-Piñero, J., Sjöström, M., Castillo-Garzon, M.J., & Ruiz, J.R. (2010). Assessing health-related fitness tests in the school setting: reliability, feasibility and safety; the ALPHA Study. *Int J Sports Med*, 31(7), 490-497.
- Font-Ribera, L., Villanueva, C.M., Nieuwenhuijsen, M.J., Zock, J.P., Kogevinas, M., & Henderson, J. (2011). Swimming pool attendance, asthma, allergies, and lung function in the Avon Longitudinal Study of Parents and Children cohort. *Am J Respir Crit Care Med*, 183(5), 582-588.
- Gerodimos, V. (2012). Reliability of handgrip strength test in basketball players. *J Hum Kinet*, 31, 25-36.
- Gibbons, J.A., Cunningham, D.A., Shaw, D.B., & Fynon, R.B. (1972). The effect of swimming training on selected aspects of pulmonary function of young girls: a preliminary report. In: *Training: scientific basis and application*. Taylor, A.W. (ed.) Springfield, NJ: Thomas.
- İmamoğlu, O., & Kilcigil, E. (2007). Left-Handedness issue at reaction time, vital capacity values and lateralization distribution of junior football players in Turkey *Spormetre Journal of Physical Education and Sports Sciences*, 5(3), 95-100.
- Kafkas, M., Taşkıran, C., Arslan, C., & Açak, M. (2009). The comparison of some physical, physiological and anthropometric parameters of junior male national and amateur badminton players, *Niğde University Journal of Physical Education and Sport Science*, 3(1), 13-20.

- Kesavachandran, C., Nair, H.R., & Shashidhar, S. (2001). Lung volumes in swimmers performing different styles of swimming. *Indian J Med Sci*, 55(12), 669-676.
- Koley, S., Kaur, S. P., & Sandhu, J. S. (2011) Correlations of handgrip strength and some anthropometric variables in Indian inter-university female handball players. *Sports Science Review*, 20(3-4), 57-68.
- Kürkçü, R., Afyon, Y.A., Yaman, Ç., & Özdağ, S. (2009). Comparison of some physical and physiologic properties of soccer players and badminton players of 10-12 years old group. *Journal of Human Sciences*, 6(1), 547- 556.
- Kürkçü, R., & Gökhan İ. (2011). The effects of handball training on the some respiration and circulatory parameters of school boys aged 10-13 years, *Journal of Human Sciences*, 8(1), 135-143.
- Lazovic-Popovic, B. Zlatkovic-Svenda, M., Durmic, T., Djelic, M., Djordjevic Saranovic, S., & Zugic, V. (2016) Superior lung capacity in swimmers: Some questions, more answer! *Rev Port Pneumol*, 22(3): 151-156.
- Massy-Westropp, N., Rankin, W., Ahern, M., Krishnan, J., & Hearn, T.C. (2004). Measuring grip strength in normal adults: reference ranges and a comparison of electronic and hydraulic instruments. *J Hand Surg Am*, 9(3), 514-519.
- Milliken, L.A., Faigenbaum, A.D., Loud, R.L., & Westcott, W.L. (2008). Correlates of upper and lower body muscular strength in children. *J Strength Cond Res*, 22(4), 1339-1346.
- Molenaar, H.M., Zuidam, J.M., Selles, R.W., Stam, H.J., & Hovius, S.E. (2008). Age-specific reliability of two grip-strength dynamometers when used by children. *J Bone Joint Surg Am*, 90(5), 1053-1059.

- Newton, R.U., Rogers, R.A., Volek, J.S., Hakkinen, K., & Kraemer, W.J. (2006). Four weeks of optimal load ballistic resistance training at the end of season attenuates declining jump performance of women volleyball players. *J Strength Cond Res*, 20(4), 955-961.
- Ölçücü, B., Cenikli, A., Kaldırımçı, M., & Bostancı, Ö. (2011). The effects of movement training with and without ball on physical fitness of tennis playing children. *Journal of Sports and Performance Researches*, 2(1), 32-40.
- Özgül, F., Eliöz, M., Otağ, A., & Atan, T. (2015). The comparison of the children group's respiratory parameters between 10-14 age who engaged in the sport of swimming. *Türkiye Klinikleri J Sports Sci*, 7(2), 35-40.
- Şahin, M., Şahin, A., Coşkuner, Z., & Çoban, O. (2011). Investigation of physical and anthropometric measurements in male children who doing taekwondo sports aged 7 to 8 years. *E-Journal of New World Science Academy (NWSA)*, 6(2), 148-158.
- Saygın, E., Karacabey, K., & Saygın, Ö. (2011). Investigation of physical activity and physical fitness of children. *Journal of Human Sciences*, 8(2), 921-935
- Saygın, Ö., Dükancı, Y., & Karacabey, K. (2009). The examination of the relationship between health-related physical fitness and the density of physical activity among the 9-11 years old boys. *E-Journal of New World Science Academy (NWSA)*, 4(3), 218-226.
- Saygın, Ö., & Dükancı, Y. (2009). The examination of the relationship between health-related physical fitness and the density of physical activity among girls. *Journal of Human Sciences*, 6(1), 320-329.
- Saygın, Ö., Polat, Y., & Karacabey, K. (2005). The effects of movement training, applied to children on their physical fitness parameters. *Firat University J Health Sci*, 19(3), 205-212.

- Silvestri, M., Crimi, E., Oliva, S., Senarega, D., Tosca, M.A., Rossi, G.A., Brusasco, V. (2013) Pulmonary function and airway responsiveness in young competitive swimmers. *Pediatr Pulmonol.* 48(1):74-80. doi: 10.1002/ppul.22542
- Vaccaro, P., & Clarke, D.H. (1978). Cardiorespiratory alterations in 9 to 11 year old children following a season of competitive swimming. *Med Sci Sports*, 10(3), 204-207.
- Van Praagh, E., & Franca, N.M. (1998). Measuring maximal short-term power output during growth. In: *Pediatric anaerobic performance*, E Van Praagh (Ed), Champaign, IL: Human kinetics, 155-189.
- Weisel, C.P., Richardson, S.D., Nemery, B., Aggazzotti, G., Baraldi, E., Blatchley, E.R. 3rd, Blount, B.C., Carlsen, K.H., Eggleston, P.A., Frimmel, F.H., Goodman, M., Gordon, G., Grinshpun, S.A., Heederik, D., Kogevinas, M., LaKind, J.S., Nieuwenhuijsen, M.J., Piper, F.C., & Sattar, S.A. (2009). Childhood asthma and environmental exposures at swimming pools: state of the science and research recommendations. *Environ Health Perspect*, 117(4), 500-5007.