Perceptual and Motor Skills, 2007, 104, 1282-1288

Muscular strength and jumping performance after handball training versus physical education program for pre-adolescent children[1, 2]

Oxyzoglou Nikolaos[1], Kanioglou Aggelos[2], Rizos Stelios[1], Mavridis George,[1] and Kabitsis Christos[1]

[1]*Laboratory of Neuromuscular Control and Therapeutic Exercise, Department of Physical Education and Sport Sciences, Aristotle University of Thessaloniki at Serres*
[2]*Laboratory of Psychology, Department of Physical Education and Sport Sciences, Aristotle University of Thessaloniki*

[1]Address Correspondence to Nikolaos Oxyzoglou, Laboratory of Neuromuscular Control and Therapeutic Exercise, Department of Physical Education and Sport Science, Aristotle University of Thessaloniki at Serres, Ag. Ioannis, 62110 Serres, Greece or e-mail (oxyzoglou@sch.gr).
[2]Authors thank Assoc. Prof. Amiridis G. Ioannis, Department of Physical Education and Sport Science, Serres, Aristotle University of Thessaloniki, Greece for advice and criticism.

Summary.- The purpose of the study was to compare a 6-month specific handball training program and a typical physical education program on various strength and jumping skills. The participants (M age = 13.7 years, SD = 1.5) were divided into the Handball Group (n = 51) and the Physical Education Group (n = 70). The Handball Group performed 3 sessions/week (60 min) including ball-handling drills, horizontal and vertical jump-shots, fast-break, and several defensive skills. The Physical Education Group performed the program provided by the Ministry of Education including track and field and other team-sport drills. Analyses of covariance showed that the handball group displayed greater improvement in explosive strength of upper limbs, jumping performance, maximum isometric force of right grip, and 10 m running velocity. These findings showed that handball training can significantly improve preadolescent performance of upper and lower limbs. The inclusion of specific handball drills into the physical education program is recommended.

Handball is on one of the many sports promoted by athletic schools. Mainstream schools provide various sporting activities such as track and field, gymnastics, team sports and dancing. The difference between these two types of school is that athletic schools largely focus on sport-training programs implemented by staff specialized in sport training whereas mainstream schools focus on cultivating general sport education mainly led by physical education instructors. The content of the two programs influences differently the development of motor abilities in children. Strength is the ability to produce maximal force, which is considered a basic motor ability and contributes to high performance in most physical activities and sports for prevention of injury (Coyle, Feiring, Rotkis, Cote, Ruby, Lee, & Wilmore, 1981; Pangrazi, 1999).

Every athletic activity influences the development of the various forms of strength. It is remarkable that strength adaptations are sport-specific and that athlete's specialization and training determine the muscle groups where the adaptations occur (Seger & Thorstenson, 2000). Numerous studies of young athletes indicated that specific training in track and field, gymnastics, swimming, soccer, basketball, improved vertical jumping performance, explosive strength of upper and lower limbs, shoulder extensor and flexor strength, and sprint performance. Gymnastics intervention program improved shoulder muscular strength and strength of lower limbs in pre-adolescent athlete (Pienaar & Van der Walt, 1988; Douda, Tokmakidis, Tsiggilis, 1997). Systematic swimming training increased the strength development of shoulder extensors and flexors (Benefice, Mercier, Guerin, & Prefaut, 1990; Malina,

1993; Amiridis, Cometti, Morlon, & Van Hoecke, 1997). Soccer, (Gorostiaga, Izquierdo, Ruesta, Inbarren, Gonzalez-Badillo, & Ibanez, 2002), basketball (Foley, 1988; Klizning, 1991), volleyball (Mills, Taunton, & Mills, 2005), and tennis training (Huff, 1972; Liemohn, 1983) improved the explosive strength of lower limbs and consequently vertical jumping performance.

Very few studies examined the effect of a handball training program on fitness characteristic in young athletes. Handball is a very dynamic team sport, requiring continuous alterations of intensity and kinetic actions, and it is characterized by a great number of side movements, jumps, throws, and body contacts all which strictly depend on muscular strength (Wolf, Tittel, Doscer, Luck, Hierse, Kiesse, Lippold, Tetzlaff, Kohler, & Schaetz, 1974).

The present aim was to compare the effects of a six month handball training with that of a typical physical education program, on explosive strength of upper and lower limbs, maximum isometric grip strength, muscular endurance of the abdomen, and 10 m running of in 12-to 14-yr-old adolescents. It was hypothesised that sport school students would display greater upper and lower limbs strength than those attending physical education programs.

METHOD

Participants

One hundred-twenty one adolescents represented two groups a Handball Group (n = 51, M age = 13.6 yr., SD = .8; M height = 168.06 cm, SD = 7.8; weight = 56.90 kg, SD = 10.35) and an Physical Education Group (n = 70, M age = 13.5 yr., SD = .9; height = 163.39 cm, SD = 10.13; weight = 57.34, SD = 11.13). The handball group included children that voluntarily participated in the training program and so were more homogeneous than children participating in the physical education program. All students were in good health, and their families signed an informed consent form prior to their inclusion in the study.

Training

The handball group training program was performed 3 times/week for 60 min over 26 weeks (total 50 training sessions). Each session was divided into warm-up (8-10 min), main training program (45 min) and recovery (5-7 min.). The main training program consisted of several exercises including: ball handling; medium and low dribbling at standing position ad while moving to all directions; holding, receiving and passing the ball with and without a jump; various shooting throws with horizontal and vertical jumps of different height; basic fakes against defense by opposing press; individual- and team- defensive skills; fast-breaks with and without press.

The Physical Education Group performed 50 sessions divided in a similar way (warm-up, main part, and recovery of total duration of 60 min.). The physical education program provided by the Ministry of Education included exercises from track and field (basic running technique, 50 m running, long jump exercises, etc.), gymnastics and various team sports such as volleyball (passing, receiving, service, etc.), basketball (dribble, pass, shoot, etc.), and soccer (pass, dribbling, control, shoot the ball, etc.).

Apparatus

A decimal measurement tape (SECA-220), a hand-dynamometer (GRIP-D, Takey, Scientific Instruments C., LTD., Tokyo, Japan), two electronic chronometers (Auto tonics Photocell, BEAM SENSOR, BLSM-MFR, Korea), and an Abalakov device were used to evaluate performance in different field tests. Instruction and

manuals were followed to evaluate the performance on the above tests and to classify individual scores (EURO FIT, 1986).

Testing procedure

The participants performed two trials of each test, and the best performance was recorded for analysis. All tests were performed before and after training and conducted at the same time of the day. The subjects performed standardized warm-up including 10 min of sub maximal running and 10 min of stretching exercises. Then, the subjects performed the following fitness tests. The standing long jump was performed with the knee, hip, and ankle, fixed at 90^o, 120^o, and 70^o, respectively. The participants were encouraged to swing their arms strongly and jump as forward as possible without any additional step. The vertical jump was performed using the Abalakov device from a squat jump (SJ) position with the knee angle fixed at 90^o. During the SJ test the arms were kept at the akimbo position to minimize their contribution. Throwing a medicine ball required the arms above and behind the head in a standing position with knee angle fixed at 90^o. Handgrip test (maximum isometric force) of the left and right hands was performed at standing position and having the arm stretched. Body sit-ups in 20 sec (repetitions) from lying position with knee angle at 90^o, while holding the arms behind the neck and lifting the body so that the elbows touch the knees. The position of the upper body was also standardized to minimize body flexion and extension of the trunk. Time of hanging (sec) from a horizontal bar with bent arms and the chin placed on the bar. Running performance of 10 m sprint from standing position.

Statistical Analysis

The SPSS 10.0 statistical package was used to analyse all data. An analysis of covariance (ANCOVA) was performed to examine the differences between groups in post-training values where the pre-training mean was used as a covariate. All data are presented as means ±standard deviation (SD) with a p value of <0.05 considered as statistically significant.

RESULTS

Analysis of covariance revealed that after the training programs the handball group demonstrated significantly ($p < 0.05$) greater values than the physical education group in the following parameters of physical fitness: long jump, vertical jump, throw of medicine ball, right hand grip, hanging from the horizontal bar, and the 10 m running velocity. However, no statistically significant differences between the two groups were found for the left hand grip and number of repetitions for body sit-ups in 20 sec. Table 1 presents the results for all fitness characteristics of the handball and physical education groups.

TABLE 1

MEANS, STANDARD DEVIATIONS, AND F RATES FOR HANDBALL AND PHYSICAL EDUCATION GROUP, TESTING ON MUSCULAR STRENGTH AND JUMPING.

Variable	Handball (n = 51)		Physical Education (n =70)		F	p
	M	*SD*	*M*	*SD*		
Long jump,	174.98±2.66		159.56±2.11		40.79	.01
Vertical jump,	43.51±6.63		39.16±6.70		13.44	.01
Throwing of medicine ball,	6.88±1.25		5.90±1.20		27.78	.01
Strength of right hand grip,	39.91±6.68		30.65±7.67		10.87	.01
Strength of left hand grip,	35.63±6.27		29.44±7.11		.15	ns
Hanging from a horizontal bar	10.04±5.66		6.23±6.43		14.46	.01
Body sit- up,	21.20±3.43		20.43±3.67		.57	ns
Starting sprint 10 m,	2.16±0.16		2.16±0.19		3.75	.05

DISCUSSION

Analysis of covariance showed that handball training improved explosive strength of the lower limbs, better than physical education group. It seems reasonable to suggest that handball characteristics (frequent throws to the goalpost accompanied by a vertical or horizontal jump, multiple vertical jump-blocks, and other offensive and defensive movements) are closely related to the kinematics and dynamic characteristics of a horizontal or vertical jump (Khosla, 1983). Our results are in line with previous studies, which showed that the team-sports, individual sports like track and field and gymnastics significantly improve jumping ability as well as neuromuscular coordination (Foley, 1988; Klizning, 1991; Gorostiaga, et al., 2002). Results generally assure that training, which includes plyometric exercises, increases the explosive strength during pre-adolescence (Brown, Mayhew & Boleach, 1986; Kellis, Kellis, Gerodimos, & Manou, 1999).

Also, the handball group displayed statistically greater explosive strength of the upper limbs than the physical education group. This difference may reflects frequent touching and pushing among the opponents (mainly during the offensive moves), the frequent transmission and receiving of the ball from long distances as well as multiple throws into the goal, which contributed to the improvement of the explosive strength of the upper limbs. These findings agree with those of other studies (Seger & Thorstensson, 2000) which documented significant differences in explosive strength of upper limbs and jumping performance between athletes and no-athletes 13 to 14 years old.

Regarding the maximum isometric strength of the hand grip, the handball training program increased the strength of the right hand grip only. Furthermore, there was no statistically significant difference for the left hand grip between the two groups. The above findings may be due to the fact that the handball group used more frequently the right hand (dominant hand) during ball handling. The results of this study also agree with previous work (Bolek 1982; Diekmann, & Letzelter, 1987).

With regard to upper limbs muscular strength, the handball team displayed greater strength than the physical education group. This finding may be related to the longer ball-handling experience the frequent defensive and offensive movements such as pushes, opponent's active stopping, ball throwing, and passing.

Abdominal muscular endurance improved but did not differ between the handball and the physical education groups. The lack of difference between the two groups may be due to the fact that the handball patterns are not such specific for the development of abdominal strength. Similar results appeared in a soccer intervention for pre-adolescent children (Siozos, 1993)

Finally, the handball group was statistically better in mean speed-strength than the physical education group. This difference may be associated with the volume and intensity of handball training, as well as to the peculiarities by which handball is characterized. The fast and frequent players' side movements during the game, the high intensity of the field moves and the star tings from the standing position are elements that contribute to the development of the speed strength (Taborsky, 2001).

In conclusion, this study demonstrated that the handball program influenced significantly the improvement in explosive strength of the upper-lower limbs, maximum strength of the right hand grips, muscular endurance of the upper limbs, and starting speed relative to those in the physical education program. Improvements in strength and jumping performance may improve the technical characteristics of a handball game. In addition, although not measured in this study, the sport schools

training staff might have contributed to the above differences owing to the greater emphasis placed on training load in the handball group.

REFERENCES

AMIRIDIS, I. G., COMETTI, G., MORLON, B., & VAN HOECKE, J. (1997) Concentric and/or eccentric training-induced alterations in shoulder flexor and extensor strength. *Journal of Orthopaedics and Sports in Physical Therapy,* 25, 26-33.

BENEFICE, E., MERCIER, J., GUERIN, M. J., & PREFAUT, C. (1990) Differences in aerobic and anthropometric characteristics between peripubertal swimmers and non-swimmers. *International Journal of Sports Medicine,* 11, 456-460.

BOLEK, E. (1982) Influence of isometrics training program in strength development handball players. *Handball,* 6, 62-70.

BROWN, E., MAYHEW, L., & BOLEACH, W. (1986) Effect of plyometric training on vertical jump performance in high school basketball players. *Journal of Sport Medicine and Physical Fitness,* 26, 1-4.

COYLE, E., FEIRING, D., ROTKIS, T., COTE, T., RUBY, F., LEE, W., & WILMORE, J. (1981) Specificity of power improvements through slow and fast isokinetic training. *Journal of Applied Physiology,* 51, 1437-1442.

DIEKMANN, W., & LETZELTER, M. (1987) Stabilitat und Wiederholbarkeit von Trainigszuwachs durch Schnellkrafttraining im Grundschlalter. *In Sportwissenschaft,* 17*,* 280-293.

DOUDA, H., TOKMAKIDIS, S., & TSIGGILIS, N. (1997) The effect of training during growth of rhythmic sports gymnastics development. *The Third Annual Congress of the European College of Sport Science.* Manchester, England, p. 676.

EUROFIT. (1986) *European test of physical fitness*. Thessaloniki, Greece: SALTO.

FOLEY, J. (1988) In-season conditioning tips for basketball. *Sport Light on Youth Sports,* 10*,* 4 -14.

GOROSTIAGA, E. M., IZQUIERDO, M., RUESTA, M., INBARREN, J., GONZALEZ-BADILLO, J., & IBANEZ, J. (2002) Effects of explosive type strength training on force production, sprint performance, endurance and serum hormones in soccer players. *Medicine and Science in Sports and Exercise,* 35, 37-45.

HUFF, J. (1972) Auditory and visual perception of rhythm by performers skilled in selected motor activities. *Research Quarterly, 43*, 197-207.

KELLIS, E., KELLIS, S., GERODIMOS, V., & MANOU, V. (1999) Reliability of isokinetic concentric and eccentric strength in circumpubertal soccer players. *Pediatric Exercise Science,* 11*,* 218-228.

KHOSLA, T. (1983) Sport for ball. *British Medical Journal,* 267, 736-738.

KLIZNING, E. (1991) Training for improved jumping ability of basketball players. *NSCA Journal*, 13, 27-32.

LIEMOHN, W. (1983) Rhythmicity and motor skill. *Perceptual and Motor Skills*, 57, 327-331.

MALINA, R. (1993) Physical activity and training: effects on stature and the adolescent growth spurt. *Medicine/Science Sports and Exercise*, 26, 759-766.

MILLS, J., TAUNTON, J., & MILLS, W. (2005) The effect of a 10-week training regimen on lumbo-pelvis stability and athletic performance in female athletes: a randomized- controlled trial. *Physical Therapy in Sport,* 6, 60-66.

PANGRAZI, R. (1999) *Teaching elementary physical education*. Boston, MA: Arizona State Univer.

PIENAAR, A., & VAN DER WALT, C. (1988) The influence of participation in a gymnastics program on selected anthropometrical variables of six to nine-year old girls. *Journal for Research in Sport Physical Education and Recreation*, 11, 39-47.

SEGER, J. Y., & THORSTENSON, A. (2000) Muscle strength and electromyogram in boys and girls followed through puberty. *European Journal of Applied Physiology,* 81, 54-61.

SIOZOS, S. (1993) Output of six months soccer training in motor abilities of children 9-11 years old. *Physical Education and Sport, 33*, 59-64. In Greek.

TABORSKY, F. (2001) Game performance in handball. *European Handball Federation Periodical.* 2, 23-26.

WOLF, G., TITTEL, K., DOSCER, I., LUCK, P., HIERSE, B., KIESS, C., LIPPOLD, G., TETZLAFF, B., KOHLER, E., & SCHAETZ, P. (1974) Statistische Analysise uber Ursachen, Lokalisationen und Arten haufiger bei Training und Wettkamp aufgetretener Verletzungen und Fehllbelastungsschaden im Hallenhandball. *Medicine und Sport,* 3, 77-80.