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THE EFFECT OF PLYOMETRIC AND STRENGTH TRAINING AFTER SIX-WEEK FOR LEG MUSCLES

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Abstract **The aim of this study is to investigate the effects of classic strength training combined with six-week plyometric muscle training on lower extremity muscle areas and strength development. This study started with 17 healthy male students at Port-Said University, but it was completed with 11 students who participate in the activities of the Faculty. The mean age of the subjects was 18.03 ± 1.37 years. At the beginning of six-week training program, certain parameters including body height, weight, calf and thigh skinfold and girds measurements were taken. In addition, vertical jump, 10 sec. multiple vertical jump, standing long jump, leg and back strength were measured. The same measurements were repeated upon the completion of the six-week strength training with plyometric exercise. The comparison of pre- and post-measurements demonstrated that vertical jump and leg strength significantly increased (p <0.01). Similarly, thigh and calf muscle areas were also significantly improved (P <0.01) after the six-week plyometric and strength training for legs.**

***Index Terms*— Plyometric training, strength gain, muscle area**

I. INTRODUCTION

Strength training has become increasingly popular in recent decades. Whereas previously strength training had been used by a few selected athletes to improve their strength and size, it is now an important component in training for most sports as well as for injury prevention and rehabilitation (Wernbom M. et al., 2007). Strength gains because of a period of resistance training are usually attributed to two major factors: neural adaptations and hypertrophy. Until recently, the prevailing opinion has been that neural adaptations play the dominant role during the first 6–7 weeks of training, during which hypertrophy is usually minor. However, it appears that the hypertrophy process begins even earlier, as trends for increased fiber CSAs can be observed at 2 weeks into the training period (Sale DG., 2003). In the latter study, further hypertrophy occurred in 6 weeks, which was also manifested at the whole muscle level (18% increase in quadriceps CSA at mid-thigh level) (Rafeei T., 1999). However, the mode of workout in strength exercise chosen for strength development and hypertrophy will gain importance for these acquisitions (Ohmor H. et al., 2010).

II. METHOD

A. Participants: This study included 17 voluntary students who attend the Faculty of Physical Education and do not participate in any sport activity or any exercise program. The study group participated regularly in strength training 3 times a week for 6 weeks.

B. Strength training workout: The training is composed of 70% intensive 10 repeated squat, leg extension, leg curl, crunch, reverse sit-up, depth jump and plyometric jump. 1 RM (repetition maximum) measurements were taken for squat, leg extension, and leg curl, and then the training was planned.

C. Measurements: Height, weight, calf and thigh skinfold and girds measurements of study group were taken. All anthropometric measurements were applied according to Anthropometric Standardization Manuel (Özer K.,1993, Özer, K. , 2001, Lohman, T.G., et al., 1988). Back and leg strengths were measured through back and leg dynamometer, and standing long jump, 10 sec multiple jump and vertical jump tests were performed (Ergo-jump Bosco System, Made by Globus.) Bosco, C.P., et al. 1983). Measurements were repeated at the end of training.

D. Calculations:

Body Mass Index (BMI) was determined by the following equation: Body Mass Index (BMI) = weight/ height (cm) 2

Extremity muscle area, fat area, and fat percentages were calculated by the following equations (Frisancho A.R., et al., 1993).

Total extremity area= C2 / 12.57
Total muscle area= (C- (Es * 3.1416))2 /12.57
Extremity fat area= total extremity area– total muscle area

Extremity fat percentage = (total extremity area– total muscle area) / muscle area) *100 C2: Extremity circumference
Es: Extremity skinfold thickness

E. Statistic: Descriptive statistics were performed for the entire group and the homogeneity of the distribution was investigated. Measurement pairs were compared by nonparametric Wilcoxon Test. The relations between variables were examined by Spearman's Rho Correlation test. Significance was set to $p<0.05$ and $p<0.01$ levels. SPSS for Windows 16.0 Software was used in all the statistical procedures.

III. RESULTS

Table 1: M±SD (Arithmetic Mean± Standard Deviation), Min (Minimum) and Max (Maximum) values for Age, Height, Weight, Body Mass Index (BMI) Variables of Study Group

n=17	Min	Max	M±SD
Age (years)	18.03	22.24	20.03±1.37
WEIGHT(kg)	54	77	67.71±7.90
HEIGHT(cm)	162	183	175.53±5.90
BMI (kg/m^2)	16.88	26.96	22.09±2.31

Descriptive statistics of age, height, weight and body mass index of the study group are shown in Table1

Table 2: M±SD (Arithmetic Mean± Standard Deviation), and p values for vertical jump (VJ), multiple jump height (MJH), Repetition Number of Multiple Jump (RNMJ), Standing long jump (SLJ), back strength (BS), and leg strength (LS) measurement pairs of the study group

	1st measurement	2nd measurement	
n=11	AM±SD	M±SD	p
VJ (cm)	41.82±17.98	43.69±19.70	0.53
MJH (cm)	37.52±4.33	36.81±5.09	0.66
RNMJ	11.20±1.90	11.64±1.57	0.23
SLJ (cm)	1.98±0.76	2.81±0.31	**
BS (kg)	145.47±34.28	148.09±23.34	0.23
LS (kg)	157.76±28.82	201.55±43.63	**

No significant difference was detected in the comparison of pre- and post-measurements of vertical jump, multiple jump, multiple jump number and back strength values of the study group ($p>0.05$). However, statistically significant difference was determined in comparison of pre- and post-measurements of standing long jump and leg strength ($p<0.01$) (Table2)(Figure 1).

Figure 1: SLJ (Standing Long Jump) Trend

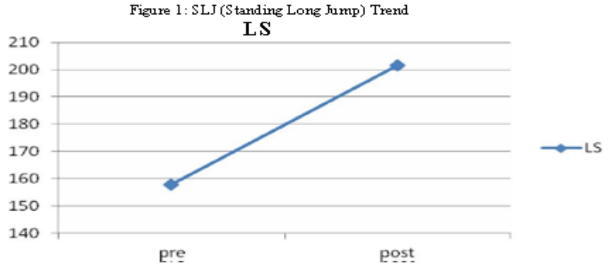

Figure 2: LS (Leg Strength) Trend

Table 3: AM±SD (Arithmetic Mean± Standard Deviation), and p values for Thigh Circumference (TC), thigh skinfold thickness (TST), total thigh area (TTA), total thigh muscle area (TTMA), thigh fat area (TFA), thigh fat percentage (TFP) measurement pairs of the study group

	1st measurement	2nd measurement	
n=11	AM±SD	AM±SD	P
TC (cm)	52.77±2.87	53.91±2.49	**
TST(mm)	11.18±4.78	11.03±4.24	0.25
TTA (cm^2)	222.22±24.44	231.72±21.56	**
TTMA(cm^2)	193.62±22.03	202.83±18.76	**
TFA (cm^2)	28.60±12.63	28.88±11.20	0.59
TFP (%)	12.78±4.95	12.36±4.44	0.11

No significant difference was observed in the comparison of the first and last measurements of thigh skinfold thickness, thigh fat area, and thigh fat percentage measurement pairs ($p>0.05$). However, there was significant difference between the thigh circumference, total thigh area and total thigh muscle area measurement pairs ($p<0.01$) (Table 3)

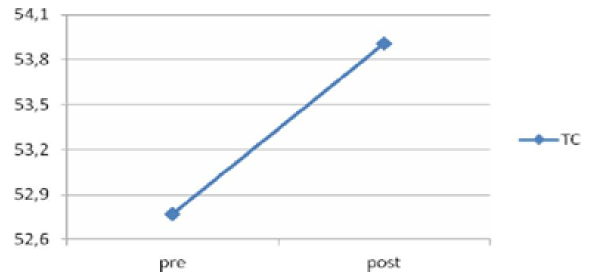

Figure 3: TC (Thigh Circumference) Chan

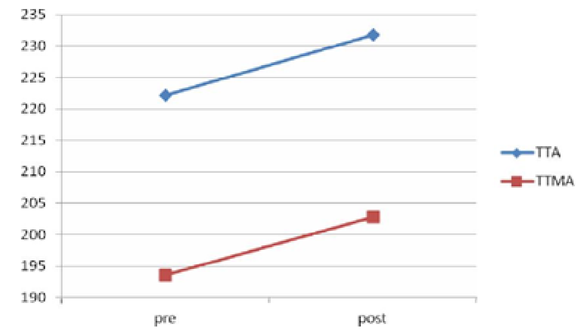

Figure 4: TTMA (Total Thigh Muscle Area) and TTA (Total Thigh Area) Changes

Table 4: AM±SD (Arithmetic Mean± Standard Deviation), and p values for calf circumference (CC), calf skinfold thickness (CST), total calf area (TCA), total calf muscle area (TCMA), calf fat area (CFA), and calf fat percentage (CFP) measurement pairs of the study group

	1st measurement	2nd measurement	
n=11	AM±SD	AM±SD	P
CC (cm)	36,54±1,43	37,32±0,98	0.05
CST (mm)	7,34±3,41	6,66±2,56	*
TCA (cm^2)	106,37±8,32	110,89±5,84	0.07
TCMA (cm^2)	93,34±7,27	98,79±5,80	**
CFA(cm^2)	13,03±6,25	12,11±4,62	0.05
CFP (%)	12,11±4,93	10,86±3,89	**

No statistically significant difference was detected in the comparison of calf circumference, total calf area, and calf fat area measurement pairs of the study group ($p>0.05$). However, the difference was statistically significant for calf skinfold thickness ($p<0.05$), total calf muscle area and calf fat percentage measurement pairs ($p<0.01$) (Table 4).

Table 5: Correlation Coefficient and Significance Level between variable

	TTMA	TCMA	BS	LS	VJ	MJH	RNMJ	SLJ
TTMA	1.00							
TCMA	0,458**	1.00						
BS	0,355*	0,175	1,000					
LS	0,357*	0,123	0,518**	1,000				
VJ	-0,150	0,198	0,360*	0,139	1,000			
MJH	0,106	0,100	0,389*	-0,037	0,583**	1,000		
RNMJ	-0,105	-0,057	-0,521**	-0,469**	-0,098	-0,215	1,000	
SLJ	0,326	0,490**	0,226	0,351*	0,476**	0,225	-0,039	1,000

IV. DISCUSSION

The mean age of the study group (n=17) was 20.03±1.37 years, the mean weight was 67.71±7.90 kg, the mean height was 175.53±5.90 cm and the mean Body Mass Index (BMI) was 22.09±2.31 kg/m2. In the literature, BMI classification is categorized as normal weight (<25), overweight (25-30) and obese (>30) (Seidell JC., 2002). BMI values of the young male group were close to upper limit, indicating overweight.

Study group was evaluated in terms of anthropometric data, vertical jump, 10 sec multiple jump, standing long jump, leg strength and back strength parameters before and after the six-week plyometric exercise.

The investigation of the effects of six-week plyometric training on thigh muscle area revealed that total thigh area and total thigh muscle area significantly increased.

The effects of increasing leg strength on thigh muscle area and thigh circumference were cited in many books related to body composition and physical exercises. Contrary to the increase in thigh, there was a decrease in calf skinfold thickness, and thus in calf fat percentage, which was an expected result of the training. Depending on the trainings, calf muscle area also increased. It was reported that quadriceps (especially vastus lateralis) muscle hypertrophy increased by around 15% with training programs containing concentric and eccentric exercises (Sanchı´s-Moysi J., et al., 2010).

Standing long jump and leg strength values were significantly improved with respect to motor tests at the end of six-week training. Plyometric training generally involves leg strength and thus the improvement in leg strength and standing long jump parameters was quite an expected situation. Vertical jump averages were inclined to increase, but this was not statistically significant. Study findings were partly compatible with the data in literature; however, the number of participants declined from 17 at the onset phase to 11 at the end of the study, which could result in certain drawbacks. More findings that are realistic can be obtained with higher number of participants.

The investigation of the relation between calf muscle area, thigh muscle area and motor tests revealed that thigh muscle area is directly proportional to leg and back strengths. A report in literature stated that leg and back strength exercises could cause hypertrophy to some extent (7). Calf muscle area was found directly proportional to standing long jump performance. Muscle volume and muscle morphology are known to increase muscle performance. It is widely accepted that the maximum force, which can be produced by a muscle, is directly proportional to its area (Maughan R.J., et al., 1983, Juha P., et al.2005)

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