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## THE PRACTITIONER'S CORNER

### Does plyometric training avoid muscle bulking and adverse change in appearance of female physical education students?

Fethi Taktak<sup>1</sup>, Ines Taktak<sup>2</sup>, Roy J. Shephard<sup>3</sup>

#### Abstract

*Background:* Female athletes who engage in competitions where performance is judged partly on appearance are sometimes concerned that intensive muscular training may produce bulky and unsightly muscles. *Purpose:* To make an objective examination of possible increases of limb bulk in response to plyometric training. *Methods:* Female physical education students (10 experimental and 10 control subjects) aged  $21.2 \pm 3.1$  and  $21.9 \pm 2.9$  years respectively undertook 8 weeks of plyometric training, with measurements of limb dimensions before and after training. *Results:* The experimental group developed expected improvements in countermovement jump scores. They showed a decrease of hip circumferences, but no change in thigh and calf circumferences; increases of muscle bulk were compensated by loss of superficial fat. Skinfolds and circumferences remained unchanged in the control group over the period of observation. *Conclusions:* It appears that plyometric training can enhance the physical performance of gymnasts without muscle bulking that could adversely affect physical appearance. **Health & Fitness Journal of Canada 2013;6(4):116-122.**

*Keywords:* Gymnastics; Jumping ability; Limb circumferences; Physical appearance; Skinfolds

From the <sup>1</sup>Higher Institute of Sport and Physical Education of Ksar Said, Tunis, Tunisia; <sup>2</sup>University "René Descartes" Paris V, France; <sup>3</sup>Faculty of Kinesiology & Physical Education, University of Toronto, Ontario, Canada.

Email: [fethi.taktak@yahoo.fr](mailto:fethi.taktak@yahoo.fr)

#### Introduction

Plyometric training is becoming a primary method of bringing the gymnast to peak performance (Asmussen and Bonde-Petersen, 1974; Cometti, 1987; Pousson et al., 1995; Young, 2003; Chu and Myer, 2013). The jumping exercises increase relaxation of antagonist muscles

significantly (Brown et al., 1986; Goubel, 1974; Huxley, 1974; Lensel and Goubel, 1987; Pousson et al., 1988), while at the same time enhancing coordination and leg strength. Matavulj et al. (2001) argued that countermovement jump training increased not only the strength of the hip extensors, but also increased the rate of development of explosive force (Bosco et al., 1983; Carrio, 2001; Hull and Hawkins, 1990; Matavukli et al., 2001). However, the gains in strength reflect largely a better synchronization of motor units and more effective use of elastic forces rather than an increase of muscle mass (Wilson et al., 1993; Chomera et al., 2004; Tricoli et al., 2005; Winchester et al., 2008; Markovik and Mikulic, 2010). This confers a practical advantage not only in disciplines where explosive force is important, but also in endurance sports, where the need to transport body mass has an important influence upon competitive performance (Bobbert et al., 1996; Cometti, 1988; Goubel, 1987; Pousson, 1988; Ramirez-Campilo et al., 2013; Schmidtbleicher, 1995).

Plyometric training is particularly helpful to athletes who already have developed good strength and speed (Siskova, 1982; Verkochansky, 1982; Zanon, 1974). The emphasis is upon enhancing the stretch/shortening cycle that is central to many body movements

in sport (Chu and Myer, 2013; Komi and Bosco, 1978; Shorten, 1987; Voigt et al., 1995; Wilkie, 1950). The leg exercises help to build effective strength for jumps and throws, while gains in flexibility allow movements of greater amplitude.

One other concern of female gymnasts and their coaches is whether muscular development may have an adverse effect upon other qualities considered in the scoring of competitors, such as grace and femininity. Here, too, plyometrics might have an advantage over resistance training. The goal of the present research was thus to evaluate the effect of plyometrics upon the external dimensions of the leg muscles and the overall physical appearance of female gymnasts.

### Methodology

#### Participants

The participants in this study were females, former gymnasts and now students in the third year of a Master of Physical Education programme at the Institute of Sport and Physical Education (ISSEP) Ksar-said in Tunis, preparing for a career as gymnastic coaches. All procedures were approved by the Institutional Review Committee for the ethical use of human subjects, according to current national and international laws and regulations. Participants gave their written informed consent after receiving both a verbal and a written explanation of the experimental protocol and its potential risks. They were told that they could withdraw from the trial without penalty at any time. They were divided arbitrarily, without formal randomization, into two groups of 10, approximately matched for gymnastic ability: an experimental group (aged  $21.2 \pm 3.1$  yr, height:  $1.71 \pm 0.08$  m, body mass

$57.5 \pm 3.6$  kg) and a well-matched control group (aged  $21.9 \pm 2.9$  yr, height:  $1.72 \pm 0.05$  m, body mass:  $56.9 \pm 3.4$  kg).

No special dietary recommendations were made, but both experimental and control groups were served the same menu in the restaurant of the Institute throughout the study.

#### *Plyometrics Training*

All study participants engaged in six 90 minute sessions of physical activity per week. The control group maintained their standard regimen throughout the study, at an energy cost of about 2.2 MJ for the 90 minute session, but for 8 weeks the experimental group replaced 3 days of their normal training period (Mondays, Wednesdays and Fridays) by plyometric sessions of 25-35 min duration, at an estimated energy cost of 2.7 MJ per session (Table 1). The duration was 35 min when light plyometric exercises were scheduled (Mondays), 30 min when moderate plyometric exercises were undertaken (Wednesdays), and 25 min if intensive plyometric exercises were performed (Fridays).

**Table 1: Programme of plyometric exercises.**

#### *Light Plyometrics*

Light plyometrics lasted for 35 min, and included the use of low plinths, leaps through hoops spaced 1.0 - 1.5 m apart, and skipping, taking stop-watch-timed rest of 1-3 min between each set.

#### *Moderate Plyometrics*

Moderate plyometrics exercises lasted 30 minutes, and included jumping through hoops set at different angles, use of a jump rope, and jumping over benches, with 1-3 min rest between each set.

#### *Intensive Plyometrics*

Intensive plyometric exercises lasted for 25 min, and included lateral jumps over a Swedish bench (with a rebound on the bench), the use of high plinths and downward jumps of 0.3 m, with 3-5 min of rest between each set.

### *Experimental Procedures*

Evaluations were made at 10.00 a.m., immediately before and two days after completing the plyometrics programme. Tests were performed in duplicate, and the best result was recorded.

### *Anthropometric Assessments*

The maximal circumferences of the hips, thighs and calves were measured with a tape as the gymnast stood on tiptoe with the arms at the side (Vandervalle, 1980). Skinfolts chosen to overlie the muscles of interest were measured with a Harpenden skinfold caliper (Lange, Cambridge, MA). The folds examined were: *supra-iliac* (70 mm above the iliac spine, in line with the anterior axillary border), *thigh* (a vertical fold was raised on the front of the thigh) and *calf* (a vertical fold on the posterior surface of the leg).

### *Jumping Ability*

Jumping ability was assessed by a counter movement jump and a counter-movement jump with the arms hanging freely. Data were collected using an Opto-jump optical measurement system (Microgate, Bolzano, Italy) to assess flight-time derived jump heights and contact times and thus assess power and relaxation to 1 msec. Such data are reliable and valid, correlating closely with force-plate estimates of the same variables (Glatthorn et al., 2011), and showing acceptable stability in control groups (Taktak et al., 2013).

*Counter-movement jump (CMJ)*. A single jump was made from the erect position. The subject stood with her hands on her hips, making a flexion-extension movement of the lower limbs; after

landing on the ground, she made a rebound jump as high as possible.

*The free arm counter-movement jump (CMJ-fa)*. A single jump was made from the erect position, with the arms hanging freely, and allowing a counter-movement.

### **Statistical Procedures**

All data were analyzed using the Statistica 6.0 software (StatSoft, Tulsa, OK), with calculation of means, 2-way ANOVAs (group x time) and Post-Hoc analysis by the LSD test, with statistical significance set at  $p < 0.05$ .

### **Results**

The body mass of both groups remained unchanged over the 8 weeks of observation (experimental =  $57.5 \pm 3.6$  vs.  $56.9 \pm 4.1$  kg; control group  $56.9 \pm 3.4$  vs.  $56.3 \pm 3.7$  kg (baseline vs. follow-up, respectively)). The jumping performance of the control group remained very stable from initial to final measurements, but following the plyometric training the experimental group showed a substantial increase of both counter-movement jump and counter-movement jump with free arms (Table 2).

The effects of plyometric training on leg dimensions are summarized in Table 3. All values for the control group again remained very constant over the experimental period. The hip skinfolts showed a significant decrease of 5.1 mm in the experimental group ( $F = 3.28$ ,  $p < 0.05$ ), with a substantial associated decrease in hip circumference ( $F = 3.20$ ,  $p < 0.05$ ).

The thigh skinfolts of the experimental group also decreased by 4.7 mm ( $F = 3.64$ ,  $p < 0.05$ ). However, in contrast to the hip measurements, the thigh circumferences remained unchanged over the 4 weeks of observation. The calf skinfolts also

## Plyometric Training and Muscle Bulk

showed a significant decrease in the experimental group ( $F = 3.26$ ,  $p < 0.05$ ), again without significant change in limb circumferences.

fibres (Malisoux et al., 2005), and if the exercise is excessive, sarcolemmal damage is also concentrated in type IIa and type IIx fibres (Macaluso et al., 2012).

**Table 2: Scores for the counter-movement jump (CMJ) and counter-movement jump with the arms hanging freely (CMJ af), before and following an 8 week interval when the experimental group completed a course of 24 plyometric training sessions (mean  $\pm$  SD of data).**

Scores (m)	Experimental group		Control group	
	Before	After	Before	After
CMJ	0.317 $\pm$ 0.032	0.389 $\pm$ 0.029***	0.321 $\pm$ 0.028	0.328 $\pm$ 0.033
CMJ af	0.344 $\pm$ 0.027	0.422 $\pm$ 0.034***	0.353 $\pm$ 0.030	0.365 $\pm$ 0.032

**Table 3: Data on skinfold thicknesses and circumferences before and following an 8 week interval when the experimental group completed a course of 24 plyometric training sessions (mean  $\pm$  SD).**

Skinfold thicknesses (mm)	Experimental group		Control group		Group x time interaction
	Before	After	Before	After	
Hip	18.4 $\pm$ 3.1	13.3 $\pm$ 2.6	18.8 $\pm$ 3.0	19.2 $\pm$ 2.5	$p < 0.05$
Thigh	16.4 $\pm$ 2.7	11.7 $\pm$ 2.9	17.1 $\pm$ 3.1	17.5 $\pm$ 2.2	$p < 0.05$
Calf	9.7 $\pm$ 2.6	7.5 $\pm$ 1.4	10.1 $\pm$ 2.9	9.8 $\pm$ 2.6	$p < 0.05$
Circumference (m)					
Hip	0.88 $\pm$ 0.05	0.84 $\pm$ 0.06	0.86 $\pm$ 0.05	0.86 $\pm$ 0.04	$p < 0.05$
Thigh	0.43 $\pm$ 0.04	0.42 $\pm$ 0.04	0.44 $\pm$ 0.04	0.43 $\pm$ 0.03	$p > 0.05$
Calf	0.32 $\pm$ 0.02	0.30 $\pm$ 0.02	0.31 $\pm$ 0.02	0.31 $\pm$ 0.02	$p > 0.05$

### Discussion and Conclusions

Classic bodybuilding techniques using resistance training develop all of the fibres in the muscles that are exercised, with a resultant increase of muscle mass, which can be a handicap in athletic disciplines where the body mass must be displaced rapidly. Less is known about the cellular response to plyometric training (Cormie et al., 2011). Available biopsy studies suggest a selective increase in the peak velocity and peak power of fast-twitch type IIa and type IIx

Further, a substantial part of the gain in jumping ability is thought due to enhanced neuromuscular coordination and better use of elastic forces (Wilson et al., 1993; Chomera et al., 2004; Tricoli et al., 2005; Winchester et al., 2008; Markovic and Mikulic, 2010). Thus, there is reason to anticipate that plyometrics may enhance performance without necessarily causing the development of bulky muscles.

At the end of the 8-week trial, our experimental subjects were indeed better trained and showed significant progress

in measures of jumping ability. However, empirical data showed a decrease rather than an increase in the hip circumferences, and no significant change in thigh and calf circumferences. Thus, any increase in muscle bulk had been compensated, or even over-compensated by an associated decrease in regional subcutaneous fat. Introduction of the plyometric sessions increased the energy expenditure of the experimental group by 0.5 MJ per session, or a total of 12 MJ over the 8 weeks. Assuming no change in diet, this would equate in itself to a loss of about 0.5 kg of fat, and additional energy would have been required for the synthesis of new lean tissue.

The measurements of skinfolds and limb circumferences suggest that fears of an ugly bulking of the gluteal, quadriceps and triceps surae muscles subsequent to plyometric training are unwarranted. Nevertheless, further study is needed. We did not make any specific ratings of overall physical appearance, and the replacement of fat by muscle may have altered contours in a manner not reflected by circumference measurements. We also examined only a small sample of women in one age group, and at one level of competition. In particular, although participants had formerly been elite gymnasts, they had subsequently gained weight, and initial skinfold readings were higher than in many gymnastic competitors; this certainly could have influenced their ability to compensate for muscle bulking by a loss of fat. There also remains a need to extend observations to male gymnasts (where expectations of appearance are different, and initial subcutaneous fat thicknesses are lower), to study the changes induced by other types and durations of plyometric training, and to

make direct comparisons with the effects of resistance training. Finally, our research leaves unanswered the philosophical question of whether the assessment of gymnastic performance should be based more upon technical skills and agility, and less upon external physical characteristics.

### Authors' Qualifications

The authors' qualifications are: Fethi Taktak S.D.; Ph. D.; Inez Taktak Ph. D student; Roy J. Shephard M.B.B.S.; M.D. [Lond.]; Ph. D.; D.P.E.; LL.D; D.Sc.

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## Plyometric Training and Muscle Bulk

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## Plyometric Training and Muscle Bulk

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