

## Reducing Training Volume during Tapering Improves Performance in Taekwondo Athletes

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### Abstract:

There is a lack of evidence on periodization models in Taekwondo. **Purpose:** This study evaluated the effects of reducing the training volume during tapering on fitness and motor performance variables in Taekwondo athletes. **Methods:** Volunteers were eight male ( $21.3 \pm 3.62$  yr.,  $75.5 \pm 16.3$  kg body weight,  $174.4 \pm 7.0$  cm body height,  $17.5 \pm 8.4\%$  body fat mass,  $VO_{2max} = 53.5 \pm 5.0$  ml·kg<sup>-1</sup>·min<sup>-1</sup>) and four female ( $19.5 \pm 1.3$  yr.,  $51.7 \pm 2.25$  kg body weight,  $160.6 \pm 5.1$  cm body height,  $26.5 \pm 6.1\%$  body fat mass,  $VO_{2max} = 45.5 \pm 4.1$  ml·kg<sup>-1</sup>·min<sup>-1</sup>) Taekwondo college athletes. The training intervention included a 10-week standardized overload phase for all participants, followed by three weeks of tapering. During the tapering phase, participants were randomly assigned to either a condition consisting of maintaining the training volume or a condition where training volume was linearly-reduced by 50%. Physical fitness and motor performance variables were measured before and after tapering. **Results:** No statistical significant group by time interactions were found on any performance variable ( $P > .05$ ). Main effects analyses showed improved performance in muscular strength ( $P = .01$ ), squat ( $P = .01$ ), counter-movement ( $P = .01$ ), arms counter-movement ( $P = .01$ ) and drop ( $P = .01$ ) jumps, and two kicking drills (kicking response time,  $P = .03$ ; kicking movement time,  $P = .04$ ). The 50% training volume tapering strategy elicited higher effect sizes and % $\Delta$  than the no reduction strategy for all performance variables. **Conclusion:** A training model using block periodization allowed improvements in Taekwondo fitness and motor performance variables regardless of the three-week tapering strategy used.

**Key Words:** Block periodization, tapering, performance, martial arts, strength, power

### Introduction

Training periodization combines scientific knowledge and coaches' expertise; its goal is to allow athletes achieve their best performance during competition (Issurin, 2008, 2010). Tapering is a feature of the periodization process that takes place right before competition and includes a reduction in training load aimed to reduce the athlete's fatigue caused by repetitive training and to eliciting the best possible performance during competition (Bosquet, Montpetit, Arvisais, & Mujika, 2007; McNeely & Sandler, 2007; Mujika, 2010, 2011; Mujika & Padilla, 2003; Murach & Bagley, 2015; Pritchard, Keogh, Barnes, & McGuigan, 2015; Pyne, Mujika, & Reilly, 2009).

There is extensive literature on tapering, with reviews on swimming, track and field and triathlon (McNeely & Sandler, 2007; Mujika, 2010, 2011; Pyne et al., 2009). However, an important limitation of these body of knowledge is the lack of evidence of tapering strategies in combat (e.g., martial arts, boxing), racquet (e.g., tennis, badminton) and precision sports (e.g., archery, shooting) (Pyne et al., 2009).

The effect size (ES), a measure of the magnitude of an intervention on a dependent variable, is considered as trivial (0-0.19), small (0.20-0.49), medium (0.50-0.79) and large ( $\geq 0.80$ ) (Cohen, 1992). The optimal tapering strategy to increase performance based on ES derived from meta-analysis (Bosquet et al., 2007), has been described as being carried out two-weeks before competition (ES = 0.59), with a training volume reduction between 41% to 60% (ES = 0.72), and maintaining the training intensity (ES = 0.35) and frequency (ES = 0.33). Based on these findings, some researchers argue that a reduction in exercise intensity is inversely related to training load; therefore, the risk of losing or not achieving biological adaptations is high. Consequently, training intensity should not be reduced; indeed, during tapering it would be desirable to increase intensity along with a reduction of the training volume (McNeely & Sandler, 2007; Mujika, 2009).

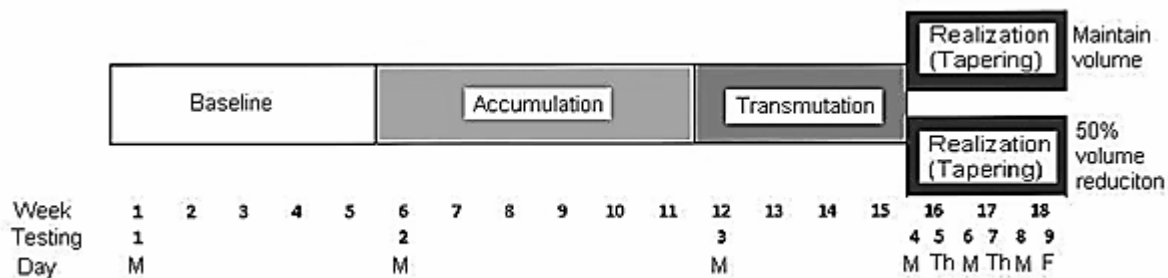
Taekwondo is a combat sport and it has been recently included as an Olympic sport; however, there is scarce empirical evidence regarding periodization models. The current reports are methodologically modest and irreproducible (Carazo-Vargas, González-Ravé, Moncada-Jiménez, & Newton, 2015). With only three specific studies on Taekwondo periodization (Ball, Nolan, & Wheeler, 2011; Harris, 2014; Ke-tien, 2012), none of them reported recommendations for a successful tapering strategy. Therefore, the purpose of this study was to

compare two tapering strategies within the context of a block periodization model in college Taekwondo athletes.

## Material & methods

### Design

This is a chronic training study where an experimental approach was chosen (Campbell, Stanley, & Gage, 1963). First, a 5-week baseline served as control for all participants, where no training or physical activity was performed. Then, participants completed a 13-week training program, consisting of 10-week overload and 3-week tapering phases. Following the overload phase, participants were randomly assigned to either an experimental condition where training volume was maintained or an experimental condition where training volume was reduced by 50% using a lineal pattern (Bosquet et al., 2007). Fitness and motor performance variables were measured at baseline, the beginning of each mesocycle, and at five different moments during tapering (Figure 1). The study protocol was submitted to, and approved by, the Scientific Ethics Committee at the University of Costa Rica. Each participant read and signed an informed consent to participate in the study.



**Figure 1.** Experimental protocol timeline. The training protocol lasted 18-weeks and included baseline, accumulation, transmutation and realization (tapering) phases.

### Participants

Volunteers were eight male and four female athletes from the University of Costa Rica's Taekwondo team. Inclusion criteria to participate in the study were: a) apparently healthy (i.e., no injuries), b) between 18 and 29 yr. age, and c) commitment to complete the training sessions without interfering with school duties. The study protocol was submitted to, and approved by, the Scientific Ethics Committee at the University of Costa Rica. Each participant read and signed an informed consent to participate in the study.

### Measurement instruments and procedures

Body height (cm) and body weight (kg) were measured with a stadiometer and an electronic scale, respectively. Body fat (%) was determined by dual X-ray absorptiometry (DXA) Lunar Prodigy Advance (General Electric, Madison, WI, USA), with enCORE 2011 software, version 13,60,033.

Maximal oxygen consumption ( $VO_{2max}$ ) was measured with a Jaeger CPX metabolic cart (CareFusion Corporation, San Diego, CA, USA). The modified Bruce treadmill protocol was used to determine  $VO_{2max}$ . Participants began walking at a pace of 2.73 km/h at 0% incline, and expired gases were collected continuously in the metabolic cart. The treadmill grade, speed or both were increased every 2-min until  $VO_{2peak}$  was achieved when meeting at least three out of four criteria: a) a plateau in  $O_2$  consumption, b) a respiratory exchange ratio ( $RER = VCO_2/VO_2 \geq 1.1$ ), c) a maximal heart rate ( $HR_{max}$ ) within 90% of the age-predicted maximum, and/or d) volitional fatigue.

Lower-body muscular strength was measured with a digital dynamometer MicroFet 2<sup>TM</sup> (Hoggan Health Industries, UT, USA). Participants performed a knee extension on a biomechanical machine. For this test, reliability proved appropriate; the intraclass correlation coefficient for intra-observer ranged from 0.82 to 0.93, for inter-session from 0.70 to 0.92 and inter-observer reliability was 0.77 (Kelln, McKeon, Gontkof, & Hertel, 2008). Lower-body muscular power was measured on a force plate Kistler<sup>®</sup> (Kistler Holding, Amherst, NY, USA). The jump tests performed were the counter-movement jump (CMJ), arm counter-movement jump (ACMJ), squat jump (SJ), and the drop jump (DJ). Three attempts were allowed on each jump type and the best performance on these was recorded in cm and used for statistical analyses.

A Fitlight Trainer System<sup>®</sup> (Fitlight Sports Corp., Ontario, Canada), was used to measure two kicking response time drills, the kicking movement time (KMT) and the kicking response time (KRT). The automated system consisted of 11.7 cm circular sensors placed conveniently according to the drill to be evaluated. The sensors were activated and deactivated when a beam of light was interrupted by the performer's kick. For the KMT drill, the athlete was instructed to use the dominant leg in a circular kick (i.e., "Bandal Chagui") to hit a single focus paddle target placed at 1.10 m height and then place the foot in the floor; then immediately, use the same leg in a circular kick to the head (i.e., "Tolio Chagui") to hit another single focus paddle target placed at 1.60 m height. Three attempts were allowed and the best performance in seconds was recorded for further

statistical analyses. For the KRT drill, two single focus paddle targets were located at 1.10 m height and two at 1.60 m height. Sensors were placed next to each paddle and randomly programmed (i.e., left, right, up, down) to be activated 0.05 s after a target was deactivated. Thus, when one of the four sensor lights was randomly turned on, the athlete had to kick the paddle to turn the light off, and 0.05 s later, a second light was randomly turned on, and so forth, until 10 lights were turned on and off. Three attempts were allowed and the best performance in seconds was recorded for statistical analyses.

The training load was measured by the Foster's method (Foster, Daines, Hector, Snyder, & Welsh, 1996), using arbitrary units (AU) to reflect the internal training load felt by a participant during a training session: Foster's index (AU) = Perceived exertion (scale 1 to 10) x Session duration (min).

#### *Experimental Protocol*

Participants completed a 5-week baseline and were instructed to rest as much as possible and avoid performing any type of structured physical training. Following baseline, athletes completed a macrocycle lasting 13-weeks. This macrocycle comprised a 6-week accumulation mesocycle, a 4-week transmutation mesocycle, and a 3-week realization mesocycle. All athletes underwent the same training sessions during the accumulation and transmutation mesocycles.

At the beginning of the realization mesocycle (i.e., tapering), participants were matched by gender and sessions attendance, then, they were randomly assigned to either an experimental condition where training volume was maintained (i.e., weekly training minutes) (group "GNR"), or an experimental condition where training volume was linearly-reduced 3.33% until the 50% from the original training volume was reached at the end of the taper (group "G50%") (Bosquet et al., 2007).

The training intervention included 64 sessions of physical, technical and tactical taekwondo training. Each session lasted 120-min, where the first 20-min included a warm-up, followed by a main phase lasting 95-min, and finally, 5-min of cool-down. The training volume reduction was designed based on the main training phase duration.

The main goal during the accumulation mesocycle was to increase strength and aerobic power throughout a high volume of basic technical and tactical taekwondo exercises. The main goal during the transmutation mesocycle was to increase power by completing fine-tuned specific technical and tactical taekwondo exercises. Finally, the main goal during the realization mesocycle was to achieve peak physical and technical performance by increasing speed and correct decision making during combat simulations (Carazo-Vargas et al., 2015).

The external training load (ETL) was estimated in AU from a subjective perceptual measure and an objective measure:  $ETL (AU) = (\text{session's effort} \times \text{volume load})/100$ ; where the session's effort represents a coaches' previous rating and the volume load represents the minutes spent during that particular training session.

During the first two mesocycles all participants were assigned the same number of sessions and training load (i.e., same assessment of session effort and same training volume). During tapering the participants also performed the same number of sessions; however, although the assessment of session effort decreased similarly between the two experimental conditions, the reduction in training volume in one of the groups generated different training loads.

#### *Testing procedures*

Dependent variables were measured at baseline, at the beginning of the accumulation mesocycle, at the beginning of the transmutation mesocycle, and at the realization or tapering mesocycle, where two assessments per week were performed for a total of six measurements (Figure 1). The dependent variable measurement order was KMT, KRT, lower-body strength, SJ, CMJ, ACMJ, and DJ. The measurement of these variables was always completed before the respective training session. These variables were measured at each of the nine measurement moments described before.

#### *Statistical analysis*

Statistical analysis was carried out using the IBM-SPSS software, version 21 (IBM Corporation, Armonk, New York). Descriptive statistics are presented as mean and standard deviation ( $M \pm SD$ ), unless otherwise noted. Dependent variables were studied by three-way ANOVA (gender x group x measurement) for the entire intervention (i.e., baseline, accumulation, transmutation, realization). Two-way ANOVA (group x measurement) were computed to analyze athlete's perception of internal workload and performance variables only during tapering. Significant interactions were followed-up by Bonferroni post hoc analyses with adjustment for multiple comparisons to avoid inflating the alpha error. Fisher's tests were performed in those cases in which this analysis did not detect differences.

Percentage change ( $\% \Delta$ ) and ES were calculated to determine the magnitude of the change from the first to the sixth measurement of the tapering phase. ES's were evaluated according to Cohen (1992). Finally, a two-way ANOVA (group x measurement) was computed to determine between-group  $\% \Delta$  between the first and the other five measurement during the tapering phase. Bonferroni tests were performed with adjustment to

follow-up statistical differences. Statistical significance was established *a priori* at  $P < .05$ , and 95% confidence intervals ( $CI_{95\%}$ ) were computed when appropriate.

**Results**

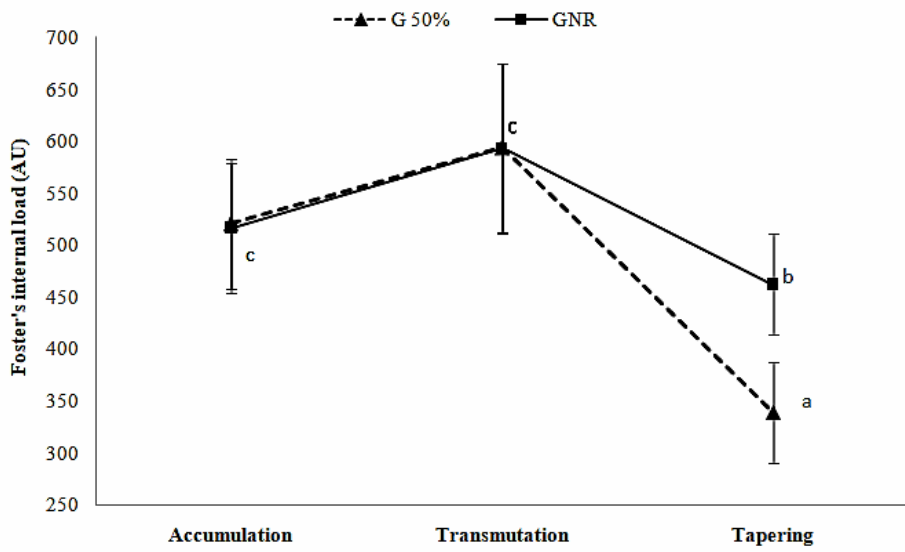
Participants mean age, weight, height, % body fat, and  $VO_{2max}$  were  $20.7 \pm 3.1$  yr.,  $67.1 \pm 11.3$  kg,  $170.4 \pm 9.5$  cm,  $20.4 \pm 8.7\%$  body fat, and  $51.0 \pm 6.0$  ml $\cdot$ kg $^{-1}\cdot$ min $^{-1}$ , respectively. For males, mean values were  $21.3 \pm 3.6$  yr.,  $75.5 \pm 16.3$  kg,  $174.4 \pm 7.0$  cm,  $17.5 \pm 8.4\%$  body fat, and  $53.5 \pm 5.0$  ml $\cdot$ kg $^{-1}\cdot$ min $^{-1}$ . For females, mean values were  $19.5 \pm 1.3$  yr.,  $51.7 \pm 2.2$  kg,  $160.6 \pm 5.1$  cm,  $26.5 \pm 6.1\%$  body fat, and  $45.5 \pm 4.1$  ml $\cdot$ kg $^{-1}\cdot$ min $^{-1}$ . Table 1 shows descriptive statistics (M  $\pm$  SD) for the dependent variables for each experimental group by study phase.

**Table 1. Descriptive statistics for dependent variables by experimental group**

	Baseline		Accumulation				Transmutation				Tapering							
	G50%	GNR	G50%	GNR	G50%	GNR	G50%	GNR	G50%	GNR	G50%	GNR	G50%	GNR	G50%	GNR	G50%	GNR
A	1.4	1.4	1.39	1.4	1.4	1.3	1.4	1.4	1.4	1.4	1.4	1.3	1.3	1.3	1.3	1.3	1.3	1.3
	$\pm 0.1$	$\pm 0.1$	$\pm 0.1$	$\pm 0.1$	$\pm 0.1$	$\pm 0.1$	$\pm 0.1$	$\pm 0.1$	$\pm 0.1$	$\pm 0.1$	$\pm 0.1$	$\pm 0.1$	$\pm 0.1$	$\pm 0.1$	$\pm 0.1$	$\pm 0.1$	$\pm 0.1$	$\pm 0.1$
B	10.7	10.2	9.6	9.4	9.6	9.5	10.0	9.7	9.4	9.8	9.7	9.5	9.4	9.5	8.9	9.7	8.5	9.6
	$\pm 1.8$	$\pm 0.9$	$\pm 1.0$	$\pm 1.5$	$\pm 1.8$	$\pm 1.6$	$\pm 1.7$	$\pm 1.6$	$\pm 1.3$	$\pm 1.2$	$\pm 0.8$	$\pm 1.1$	$\pm 1.0$	$\pm 1.4$	$\pm 0.1$	$\pm 1.9$	$\pm 0.5$	$\pm 1.9$
C	350.7	437.0	370.0	443.4	383.5	470.4	415.2	403.8	413.8	488.6	415.6	470.6	481.2	476.6	410.9	488.0	432.5	488.8
	$\pm 141.7$	$\pm 133.4$	$\pm 151.0$	$\pm 127.5$	$\pm 160.3$	$\pm 115.0$	$\pm 145.2$	$\pm 156.3$	$\pm 145.8$	$\pm 153.9$	$\pm 133.6$	$\pm 155.1$	$\pm 132.3$	$\pm 139.3$	$\pm 134.4$	$\pm 177.2$	$\pm 153.6$	$\pm 148.6$
D	29.0	29.8	27.6	26.8	28.1	26.8	29.7	27.6	29.0	29.0	30.8	28.6	31.4	28.8	30.4	28.1	32.0	29.5
	$\pm 4.5$	$\pm 6.8$	$\pm 4.9$	$\pm 6.6$	$\pm 3.2$	$\pm 5.7$	$\pm 3.5$	$\pm 4.6$	$\pm 4.7$	$\pm 5.5$	$\pm 4.5$	$\pm 5.3$	$\pm 5.0$	$\pm 5.1$	$\pm 5.0$	$\pm 5.9$	$\pm 4.2$	$\pm 6.2$
E	32.7	30.3	29.4	27.5	30.3	28.2	32.2	29.6	30.8	30.1	32.4	29.7	33.6	30.9	32.3	29.7	34.4	31.2
	$\pm 5.3$	$\pm 7.9$	$\pm 5.2$	$\pm 7.2$	$\pm 6.3$	$\pm 6.8$	$\pm 4.6$	$\pm 5.7$	$\pm 6.0$	$\pm 6.4$	$\pm 4.6$	$\pm 6.2$	$\pm 6.1$	$\pm 5.9$	$\pm 6.1$	$\pm 6.3$	$\pm 5.8$	$\pm 6.7$
F	35.4	35.2	33.8	34.5	30.3	28.2	35.5	34.7	35.7	34.8	35.7	35.1	37.0	36.0	35.3	34.2	38.2	34.9
	$\pm 7.8$	$\pm 10.8$	$\pm 6.4$	$\pm 8.9$	$\pm 6.3$	$\pm 6.8$	$\pm 6.0$	$\pm 7.2$	$\pm 6.4$	$\pm 7.4$	$\pm 5.6$	$\pm 8.1$	$\pm 5.8$	$\pm 8.9$	$\pm 6.8$	$\pm 7.9$	$\pm 6.2$	$\pm 7.1$
G	30.9	30.8	29.7	27.8	29.8	26.8	31.2	28.8	31.6	30.0	33.2	28.7	31.9	30.0	31.1	28.5	33.7	29.9
	$\pm 6.5$	$\pm 7.6$	$\pm 6.1$	$\pm 6.4$	$\pm 5.7$	$\pm 6.2$	$\pm 5.1$	$\pm 5.0$	$\pm 5.5$	$\pm 7.0$	$\pm 4.4$	$\pm 5.7$	$\pm 6.0$	$\pm 6.9$	$\pm 6.2$	$\pm 6.6$	$\pm 5.0$	$\pm 6.1$
H	51.6	30.3	53.7	54.4													36.1	54.3
	$\pm 6.7$	$\pm 5.9$	$\pm 5.3$	$\pm 7.3$													$\pm 6.2$	$\pm 6.2$
I	21.0	19.8	22.6	20.9													19.6	18.1
	$\pm 8.9$	$\pm 9.2$	$\pm 8.3$	$\pm 10.1$													$\pm 8.7$	$\pm 9.4$

Note: A: kicking reaction time (s); B: kicking movement time (s); C: strength (N/m $^2$ ); D: squat jump (cm); E: counter-movement jump (cm); F: counter-movement jump with arms (cm); G: drop jump (cm); H: maximal oxygen consumption (ml $\cdot$ kg $^{-1}\cdot$ min $^{-1}$ ); I: body fat mass (%). G50%: group with 50% reduction during tapering; GNR: group with no reduction during tapering.

The overall attendance to the training sessions was 90.6%, and no between-group differences were found ( $P = .640$ ). A group  $\times$  measurement interaction was found ( $P = .02$ ) when examining whether volume training reduction elicited a decrease in the internal workload of the athletes. During tapering, the G50% reported a lower internal workload ( $338.56 \pm 54.10$  AU,  $CI_{95\%} = 289.81, 387.32$ ) compared to the GNR ( $462.01 \pm 53.09$  AU,  $CI_{95\%} = 413.25, 510.76$ ). A lower internal workload was reported by participants in the G50% during tapering than during the first two mesocycles (Accumulation =  $520.44 \pm 62.59$  AU,  $CI_{95\%} = 458.24, 582.64$ ; Transmutation =  $593.48 \pm 93.95$  AU,  $CI_{95\%} = 512.01, 674.95$ ). The GNR showed lower internal workloads during tapering than during the transmutation phase ( $592.81 \pm 84.94$  AU,  $CI_{95\%} = 511.34, 674.28$ ) (Figure 2).



**Figure 2.** Between-group internal workload according to training mesocycle. Y-axis values represent Foster's arbitrary units (AU). Different letters (a, b, c) indicate significant mean differences between measurements  $P < .05$ .

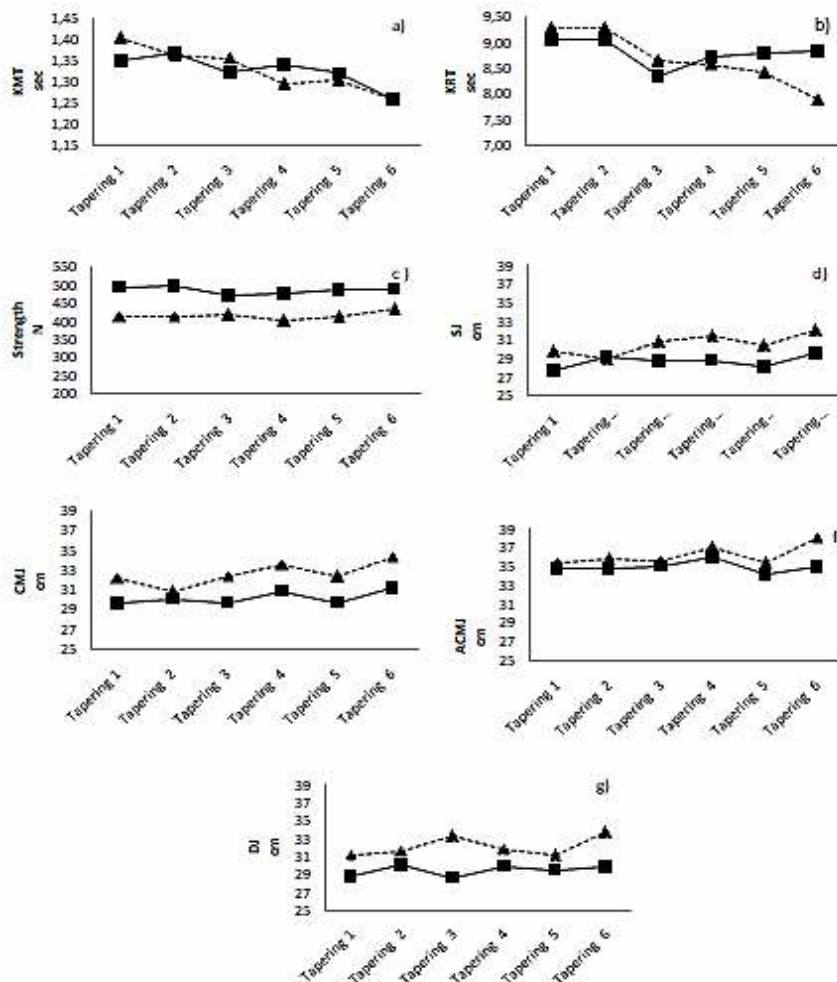
The results obtained by the 3-way ANOVA for each dependent variable during the complete intervention allowed us to identify a similar evolution pattern of the variables between groups and gender over time. Table 2 shows the ANOVA summary results corresponding to the tapering phase, moment when participants were randomly distributed to the experimental conditions.

**Table 2.** ANOVA summary table for the dependent variables during tapering.

Variable	Main effect				Interaction	
	Measurement (A)		Group (B)		A x B	
	F=	P≤	F=	P≤	F=	P≤
KRT	12.01	.01	0.01	.92	2.06	.09
KMT	3.43	.01	0.04	.84	1.62	.17
Strength	0.78	.57	0.69	.43	0.44	.82
SJ	2.52	.04	0.51	.49	0.96	.45
CMJ	5.14	.01	0.68	.43	0.58	.71
ACMJ	2.93	.02	0.14	.72	0.93	.47
DJ	2.05	.09	0.71	.42	1.54	.19

Note: KRT: kicking reaction time (s); KMT: kicking movement time (s); Strength (Newtons); SJ: squat jump (cm); CMJ: counter-movement jump (cm); ACMJ: counter-movement jump with arms (cm); DJ: drop jump (cm).

There were no interactions between groups and measurements in the seven dependent variables (Figure 3). Main effect differences were found regardless of the experimental group in five dependent variables.



**Figure 3.** Between-groups and measurements interactions for the dependent variables during tapering. Note: a) kicking reaction time (s), b) kicking movement time (s), c) Strength in Newtons, d) squat jump (cm), e) counter-movement jump (cm), f) counter-movement jump with arms (cm), g) drop jump (cm). The groups are: a) G50% (▲) and b) GNR (■).

Performance on KMT was better in the sixth tapering measurement compared to all the other measurements ( $P=.01$ ). The first tapering measurement showed the lowest performance, the second tapering measurement also showed a poor execution compared to the fourth, fifth and sixth tapering measurements (Figure 3a). The performance change from the first to the sixth tapering was large ( $ES = 1.29$ ) for this variable (a positive ES denotes an improvement in KMT).

Participants performed better on the KRT variable in the sixth and third tapering measurements compared to the first and second ( $P=.01$ ). Baseline measurement showed a longer KRT than the third measurement (Figure 3b). The performance change from the first to the sixth measurement was medium ( $ES = 0.58$ ) for this variable (a positive TE denotes an improvement in the KRT).

No differences were found in strength (Figure 3c). The change from the first to the sixth tapering measurements showed a trivial  $ES = 0.04$ .

Lower-limb power, as determined by SJ performance, was lower during the measurement of the initial tapering than the sixth measurement ( $P=.04$ ). In addition, there were differences between the fifth and sixth tapering measurements (Figure 3d). The change from the first to the sixth tapering measurements were medium as shown by an  $ES = 0.51$ . The jumping ability as determined by CMJ performance was lower during the initial measurement than during the fourth and sixth tapering measurements ( $P=.01$ ). The sixth measurement was higher than all other measurements, except for the fourth measurement. In addition, the fourth measurement was higher than the second and fifth measurements (Figure 3e). There was a small  $ES = 0.36$  from the first to the sixth tapering measurements. The jumping ability as determined by ACMJ performance was higher during the sixth measurement than during the first, second and fifth tapering measurements ( $P=.02$ ), and the fourth was higher than the fifth measurement (Figure 3f). There was a small  $ES = 0.23$  from the first to the sixth tapering measurements. Finally, no statistical interactions were found on the DJ performance (Figure 3g). The change from the pre-test to the sixth tapering measurement showed a small  $ES = 0.36$ .

Effect sizes and  $\% \Delta$  between the first and sixth tapering measurements by experimental groups is shown in table 3. For both analyses, higher values were found in the G50% compared to the GNR condition.

**Table 3.** Effect sizes (ES) and percent change ( $\% \Delta$ ) between the first and sixth tapering measurements. For ES and  $\% \Delta$  a positive sign indicates improvements in performance.

Variable	Effect Size			$\% \Delta$		
	G50%	GNR	All participants	G50%	GNR	All participants
KRT	1.49	1.08	1.29	11.71	7.25	9.48
KMT	0.88	0.18	0.58	16.94	2.92	9.93
Strength	0.12	-0.03	0.04	3.85	-0.76	1.54
SJ	0.64	0.41	0.51	6.77	5.33	6.05
CMJ	0.47	0.27	0.36	5.98	4.27	5.12
ACMJ	0.45	0.03	0.23	6.91	0.60	3.75
DJ	0.49	0.22	0.38	7.36	2.86	5.11
<b>Mean</b>	<b>0.65</b>	<b>0.31</b>	<b>0.48</b>	<b>8.50</b>	<b>3.21</b>	<b>5.84</b>

Note: KRT: kicking reaction time (s); KMT: kicking movement time (s); Strength in Newtons; SJ: squat jump (cm); CMJ: counter-movement jump (cm); ACMJ: counter-movement jump with arms (cm); DJ: drop jump (cm); G50%: group with 50% reduction during tapering; GNR: group with no reduction during tapering.

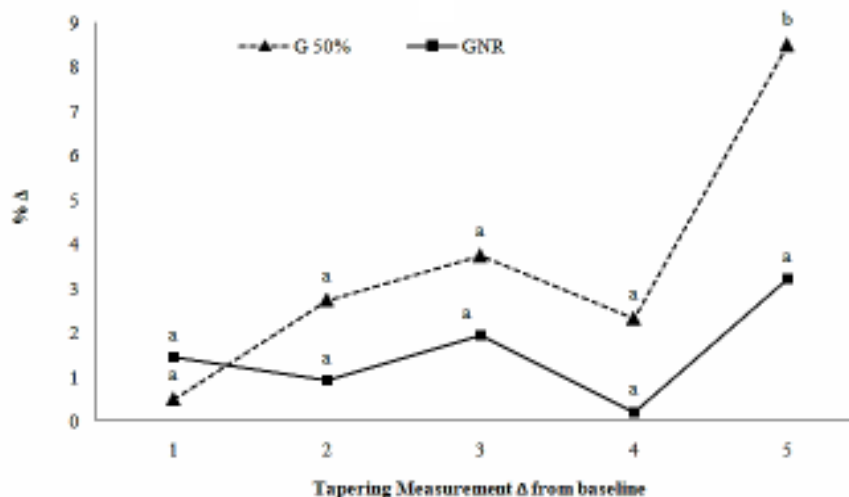
Presented in table 4 are descriptive statistics by tapering stage for the G50% and GNR groups for the overall global change.

**Table 4.** Global percent change ( $\% \Delta$ ) from the beginning of the tapering phase.

$\% \Delta$	G50%	GNR
To 2 <sup>nd</sup> measurement	0.56 ± 8.57	1.49 ± 6.75
To 3 <sup>rd</sup> measurement	2.74 ± 8.51	0.92 ± 8.49
To 4 <sup>th</sup> measurement	3.74 ± 8.23	1.94 ± 6.73
To 5 <sup>th</sup> measurement	2.32 ± 9.99	0.21 ± 8.75
To 6 <sup>th</sup> measurement	8.50 ± 8.39	3.21 ± 7.03

Note: G50%: group with 50% reduction during tapering; GNR: group with no reduction during tapering.

The two-way ANOVA (group x measurement), showed an interaction between groups and measurements ( $P=.005$ ) on  $\% \Delta$ . In the G50% group the change reached during the sixth measurement was greater than in the other measurements. When comparing the measurements between groups, a greater  $\% \Delta$  was observed during the sixth measurement in the G50% than in the GNR (Figure 4).



**Figure 4.** Global percent change (%Δ) from first measurement during tapering by experimental group. Different superscript letters denote between-measurement differences at  $P < .05$ .

### Discussion

This study evaluated the effects of reducing the training volume during tapering on selected fitness and motor performance variables in Taekwondo athletes by using a block periodization model. The present study is pioneer in the analysis of the periodization and tapering in Taekwondo competitors. The main finding was the effectiveness of the block periodization model to optimally prepare a Taekwondo competitor. We also agreed with previous evidence (Bosquet et al., 2007), showing greater benefits on KRT, KMT, strength, power, aerobic capacity and body composition when reducing the training volume in the tapering phase. Regardless of whether there was a reduction in the volume of training or not during tapering, in most of the fitness and motor variables analyzed the best performance was shown at the end of the third week.

Meta-analytic evidence (Bosquet et al., 2007), suggests that the optimal tapering is reached with a reduction in training load lasting two-weeks, a reduction in training volume, and without reductions in training intensity or frequency. In this study, ES's analyses showed trivial to large improvements in fitness and motor variables during three weeks of tapering regardless of the training volume and without reducing training frequency and intensity.

The absence of significant interactions between groups and measurements, contrasts with the higher %Δ and ESs in the reduced training volume condition during tapering. In this study, the maximum number of participants that was included in each group was 6 people. Taking into account that these should be competitors of a prominent level, increasing the sample size was unrealistic. Even so, the small number of participants coincides with samples previously reported in the literature (Ball et al., 2011; Gomes et al., 2013; Hellard et al., 2005; Ke-tien, 2012; Mah, Mah, Kezirian, & Dement, 2010; Papacosta, Gleeson, & Nassis, 2013; Santhiago, Da Silva, Papoti, & Gobatto, 2011).

The study and comparison of tapering models is limited (Mujika, 2009; Mujika & Padilla, 2003; Pritchard et al., 2015); therefore, we followed previous evidence from literature reviews and meta-analysis to ground the present study (Bosquet et al., 2007; Mujika & Padilla, 2003), which represented the most feasible way to scientifically justify the methodological design. The meta-analysis by Bosquet et al. (2007), investigated dependent variables in sports as measured by time (e.g., swimming, cycling and running). Although the evidence allowed us to design our study intervention, we acknowledge that Taekwondo is a completely different sport and the results comparison might not be the most appropriate, yet, it is the closest. Nevertheless, the congruent findings to those reported by Bosquet's group is remarkable.

A limitation of this study was that we did not measure biochemical, endocrine, neuromuscular, or immunological variables that might have allowed us to explain, from a biological perspective, the performance improvements found following tapering (Gomes et al., 2013; López & Fernández, 2006; Murach & Bagley, 2015; Nemet, Lustig, Davidov, Meckel, & Eliakim, 2008; Viru & Viru, 2001). Although a significant reduction of 50% in the training volume was used at the end of the third week of the training load reduction, we followed a conservative reduction at the beginning of the tapering using a linear model (i.e., a constant decrease of 3.33% in each session). The use of an exponential tapering model could benefit physical performance of competitors since tapering aims to maximize recovery (Campos & Cervera, 2011; DeWeese, Gray, Sams, Scruggs, & Serrano, 2013; Issurin, 2010; McNeely & Sandler, 2007) and applying an exponential model with rapid reduction represents a more intense discharge stimulus than a linear model (Mujika & Padilla, 2003). Thus, the tendency shown in the inferential analysis, in which a better performance was observed in the sixth tapering measurement in the G50%, could reach statistical significance; however, this hypothesis requires further empirical support.

### Practical applications

The evidence analyzed has important implications for those responsible for preparing the athletes and for the athletes themselves. The inadequate application of the findings reported in the scientific literature have two important risks, the failure to reach a true tapering and the risk of developing the overtraining syndrome (Murach & Bagley, 2015). Making the right decisions to apply the necessary training loads that lead to the achievement of optimal adaptations, must arise from the analysis of individual behavior evaluations. The use of inadequate training loads will increase the risk that some athletes arrive to the competition without having reached their maximum potential to perform and that others may accumulate an overload that could lead them to overtraining.

The evidence presented supports the need to reduce the training volume by 50% as an effective strategy to increase performance. This reduction should be made in parallel with an increase in intensity. Two weeks were insufficient to reach a maximum performance in the physical variables studied. In addition, although the technical-tactical conditions were not part of the study variables, it is considered that a period of less than three weeks is not enough to reach an optimal tactical level, especially in Taekwondo, whose result is closely related to the ability to make decisions in short periods of time during an actual combat.

### Conclusions

A training model using block periodization allowed improvements in Taekwondo performance-related variables regardless of the three-week tapering strategy used. New training models using periodization blocks should be explored in other contact sports.

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### Declaration of interest

The authors report no conflict of interest.

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