COMPARING PERIODISED PROTOCOLS FOR THE MAINTENANCE OF STRENGTH AND POWER IN RESISTANCE-TRAINED WOMEN

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Abstract

Purpose: The purpose of the study was to compare the effects of daily undulating periodisation (DUP) and session undulating periodisation (SUP) for maintaining strength and power over a 3-wk period in a group of resistance-trained women. DUP comprised one session each of strength and power training while DUP combined both strength and power training within each session. Both training programmes were equalised for training volume and intensity. **Methods:** Sixteen resistance-trained women were pre-tested for body mass, mid-arm and mid-thigh girths, one-repetition maximum (1 RM) dynamic squat (SQ) and bench press (BP), and power during countermovement jumps (CMJ) and bench press throws (BPT). The 1 RM SQ and BP data were used to assign the participants into groups for twice a week training. **Results:** A two-way (group x time) analysis of variance (ANOVA) with repeated measures for time found no significant changes in body mass, mid-arm girth, 1 RM BP and SQ, and BPT and CMJ power for both groups. However, significant changes in mid-thigh girth were found ($F_{1, 13} = 5.733$, $p = 0.032$). Pooled BP data indicated improved upper body strength (BP: $F_{1, 13} = 6.346$, $p = 0.025$) and decreased CMJ power ($p = 0.016$). **Conclusions:** Both DUP and SUP programmes increased upper-body strength and maintained lower-body strength adequately across a 3-wk phase probably because the participants were weaker in the upper-body and the lower-body had a reduced capacity for strength adaptations and improvements.

Keywords: Strength, power, periodisation, in-season maintenance

Introduction

Periodisation of resistance training organises training into phases that systematically emphasise different strength qualities in order to help athletes attain peak conditions prior to competition (Hartmann et al., 2015; Stone, O'Bryant, & Garhammer, 1981), and to reduce staleness and overtraining (Fleck & Kraemer, 2003). These peak levels of hypertrophy, strength, power and/or muscular endurance then need to be maintained throughout a competition period (or in-season phase) when the increase in technical and tactical training may lead to reduced training volumes which in turn, may result in a decrease in muscle mass subsequently leading to a decline in strength, power, and sport performances (Allerheiligen, 2003). Studies examining in-season changes in athletes from sports such as swimming, basketball, rugby, and soccer have reported decrements in strength and power during a competitive period (Baker, 1998; Issurin, 2010). The use of maintenance training may help avert this phenomenon.

Studies that have examined maintenance training are scant, and those few studies indicated that strength and power were increased in previously untrained participants (DeRenne, Hetzler, Buxton, & Ho, 1996), but were only maintained at pre-competition levels in previously resistance-trained participants (Baker, 2001). As untrained populations tend to show improved performances regardless of the type of training programme, the results from untrained participants need to be viewed with caution. A more recent investigation however, demonstrated promising results for maintenance training in resistance-trained football players (Hoffman, Wendell, Cooper, & Kang, 2003), contradicting earlier research that maintenance training could only maintain strength qualities in previously-trained males (Baker, 2001). Thus, the discrepancy needs further investigation.

While strength and power training protocols have been well documented, little attention has been given to protocols for the maintenance of strength qualities. Strength and power development has usually adhered to one of two basic models of periodisation, linear or undulating periodisation. Linear periodisation (LP) typically begins with high volume but low intensity, and the programme shifts to lower volume but higher intensity by the end of the training mesocycle (Stone, O'Bryant, & Garhammer, 1981). The mesocycle is divided into phases, with one strength component (hypertrophy, maximal strength or power) emphasised in each phase based on the programmed intensity of training. Undulating periodisation (UP) involves alternating high and low intensity regularly, emphasising different strength components on a daily or weekly basis (Fleck, 1999). Most UP studies have utilised one day a week for hypertrophy, strength and power training respectively (Kraemer, 2003; Newton, 2002; Rhea, Ball, Phillips, & Burkett, 2002). These descriptions however, do not readily fit the protocols that were utilised in the few studies that examined periodised maintenance training (Baker, 2001; Hoffman, Wendell, Cooper, & Kang, 2003).

One study (Baker, 2001) utilised a form of UP that adjusted intensity to include the training of hypertrophy, strength and power within a training session while the other (Hoffman, Wendell, Cooper, & Kang, 2003) compared a LP model that involved training at 80 % intensity for both days of training, with a UP model that consisted of training at an intensity of 70 % intensity on one day, and 90 % on the other. A point of contention in the study mentioned above was that the experimental groups were formed across two competition seasons, with one group of freshman footballers adhering to LP in the first year, and another group of freshman performing UP during the second year. Although it was suggested that both groups of freshman would have similar training backgrounds and resistance training experience (Hoffman, Wendell, Cooper, & Kang, 2003), it is methodologically more accurate to compare both groups within a common training period. Although LP was found to be more effective than UP in eliciting strength gains during a 12-wk maintenance phase (Hoffman, Wendell, Cooper, & Kang, 2003), more research is needed on both LP and UP designs.

In addition, only one study (Bell, Syrotuik, Attwood, & Quinney, 1993) was found to have utilised female participants in a strength maintenance study, and no published studies can be found that have examined the effects of periodised maintenance training on strength and power in resistance-trained women. This is in spite of increased female participation in many sporting activities and competitions, and emphasises the need for more studies on strength and power maintenance in women. Therefore, the purpose of the present study was to examine the effects of two UP maintenance programmes on strength and power in a group of resistance-trained women. The responses of various tests related to strength and power were scrutinised after a 3-wk maintenance programme. This duration was selected as it has been suggested that previously resistance- and power-trained males experienced a loss in strength after approximately 2 wk of detraining (Fleck, 1994). As comparisons between training programmes are usually more effective if training volume and intensity are equalised between groups, the design of the two comparative programmes resulted in a similar overall training volume (repetitions x sets x load lifted) and intensity. It was hypothesised that previously resistance-trained women would not obtain increases in strength and power after a short period of maintenance training. Additionally, there would be no difference between the two UP protocols for maintaining strength qualities in previously resistance-trained women.

Material and Methods

Participants

Participants consisted of 16 females from the university population who had at least nine months of resistance-training experience prior to the study, but who were not competitive strength athletes. The participants had no medical or physical conditions that could limit their participation. After the potential risks of participating in the study were explained, all participants gave written informed consent, and limited their training activities to only the designated sessions of the study. They were also asked to maintain similar dietary and activity habits throughout the experimental period. The study had the approval of the institution's Human Ethics Committee. One participant pulled out due to reasons unrelated to the study, and the remaining participants completed 100 % of the training sessions. Of the remaining participants, the mean (± SD) subject characteristics for age, mass and height were 22.2 ± 4.3 y, 64.6 ± 12.3 kg, and 168.8 ± 8.6 cm respectively.

Procedure & Instrumentation

Pre-tests were performed before three weeks of maintenance training, with post-tests following immediately. As one participant pulled out before the start of the experimental period, the 15 remaining participants were assigned (using the A-B-B-A procedure) into two training groups based on their squat index (one-repetition maximum [1 RM] squat / body mass), and the closest possible match for the bench press index (1 RM bench press / body mass) scores. One group performed strength training on Monday and power training on Thursday (daily undulating periodisation, DUP), while the other group performed both strength and power training within the same training session (session undulating periodisation, SUP) as shown in Table 1. Strength training was performed at 85 % of 1 RM while power training was performed at 40 % of 1 RM as these loads were found to be the suitable loads for achieving strength and power objectives in previous training studies for women (16). Pretest 1 RM scores were used to calculate training loads for the bench press (BP) and squat (SQ), while loads for the other exercises were based on the participants' 6 RM loads performed during training prior to the start of the 3-wk maintenance phase. These 6 RM loads were estimated to be 85 % of 1 RM (2), and the load closest to 40 % of estimated 1 RM was then calculated and used for power training. Using a combination of the percentage of 1 RM (for the BP and SQ) and the RM methods (for all other exercises) helped ensure the intensity of training remained within the set level.

Table 1: Undulating protocols for strength and power maintenance in daily undulating periodisation (DUP) and session undulating periodisation (SUP) groups for the experimental period (wk 1-3).

	Monday	Thursday
DUP	<u>Strength:</u> $\frac{85}{6}4$	<u>Power:</u> $\frac{40}{8}4$
SUP	<u>Strength & Power:</u> $\frac{85}{6}2$; $\frac{40}{8}2$	<u>Strength & Power:</u> $\frac{85}{6}2$; $\frac{40}{8}2$

$$\left[\frac{85}{6}2\right] \text{ denotes } \left[\frac{\%\ \text{of}\ 1\text{RM}}{\text{repetitions}}\ \text{number of sets}\right]$$

Both DUP and SUP groups performed the same exercises in the same order. However, the rest periods and timing of the movement were dependent upon whether the training objective was for maximal strength or power (Table 2). Training for strength was performed using 4 s for the entire action, while training for power was performed by lowering the equipment in a controlled manner before pushing explosively as quickly as possible. Each power repetition was performed with maximal explosive effort, but the barbell or weight implement was not projected (released from contact with subject) at the end of movement. For each exercise, the SUP group always trained the power sets before the strength sets. Daily training volume (total repetitions per set x number of sets x mass lifted per set) was recorded for each exercise throughout the entire training period, while weekly volume totals were prepared and analysed.

Table 2: Exercises, sequence, rest and pace of movement used during training.

Exercise order	Exercise	Rest (min) ;sets		Cadence (s•repetition^{-1})	
		S	P	S	P
1	Squat to 110°	2;2 or 4	2;2 or 4	4	Afap
2	Bench press	2;2 or 4	2;2 or 4	4	Afap
3	Abdominal exercise	2-3 sets of 10-20 repetitions every session			
4	Leg press	2;1 or 2	2;1 or 2	4	Afap
5	Shoulder press	2;1 or 2	2;1 or 2	4	Afap
6	Back exercise	2-3 sets of 10-20 repetitions every session			
7	Lunge	2;1 or 2	2;1 or 2	4	Afap
8	Lat pull-down	2;1 or 2	2;1 or 2	4	Afap
9	Heel raises	2;1 or 2	2;1 or 2	4	Afap
10	Pec press	2;1 or 2	2;1 or 2	4	Afap

S = Maximal strength training, P = Power training, Afap = As fast as possible

Pre- to post-test changes were assessed through the following tests in the order presented to minimise fatigue – body mass, mid-arm and mid-thigh girth measurements, 1 RM dynamic SQ, CMJ, 1 RM dynamic BP and the BPT (Kok, Hamer, & Bishop, 2009). All tests were performed on the same day, and there was a minimum of 15 min for recovery between tests. Similar positions were used each time the participants were tested as hand and foot positions for the strength and power tests had been previously determined and recorded. This helped ensure reliability of position. Each subject performed standardised warm up and cool down procedures (Kok, Hamer, & Bishop, 2009) prior to and after testing and training. For training sessions, the participants would warm up by performing one set of SQ or BP for 10 repetitions using approximately half the training load. This was followed by the actual training set. Exercises following these first two exercises would go immediately into the training activity as similar muscles had already been used, and an additional warm up set would just become additional unrecorded training volume. Warm up for power training would use the power load as the warm up set performed in a slow and controlled manner for 10 repetitions.

Statistical Analysis

Descriptive statistics were used to derive means ± SD and percent changes for all variables. Confidence intervals were also calculated and reported where appropriate. Pre-test demographic and strength data were evaluated for between-group differences using independent *t*-tests to assess if the two groups differed in any significant way prior to training. Independent *t*-tests were also performed on weekly and total training volumes as this verified that training volumes were approximately equal between the groups; abdominal and back exercises however, were excluded from the analysis. Pre- and post-test data were analysed using a two-way (group x time) analysis of variance (ANOVA) with repeated measures for time. Dependent *t*-tests were used for within-group comparisons while independent t-tests were employed to compare between-groups changes when significant interactions were detected. Statistical significance was set at $p \leq 0.05$, but differences that were significant at $p \leq 0.10$ are also reported. Effect sizes (ES) were reported whenever appropriate to assess pre- and post-test changes and pooled standard deviation (SD) was used when the SDs from both means in comparison were unequal. Effect sizes of 0.2 represented small differences, 0.5 represented moderate differences and 0.8 represented large differences (Cohen, 1988). All statistical analyses were performed through the use of a statistical software package (SPSS version 16, SPSS Inc., Chicago, IL, USA).

Results

Subject Characteristics

No significant pre-test differences between the two training groups were detected for age, mass, height or upper- and lower-body strength. Means (SD) as well as *t* and *p* values for each of the parameters mentioned are shown in Table 3.

Table 3: Pre-training demographic and strength data for daily undulating periodisation (DUP) and session undulating periodisation (SUP) training groups. All values are mean (± SD).

Measure	DUP	SUP	t value	p value
No. of participants (n)	8	7	NA	NA
Age (y)	21.6 (3.3)	22.9 (5.5)	0.534	0.603
Mass (kg)	63.62 (10.44)	65.77 (14.99)	0.326	0.750
Height (cm)	169.2 (9.2)	168.4 (8.6)	0.169	0.868
Baseline 1 RM SQ (kg)	134.9 (23.0)	143.7 (18.9)	0.807	0.434
1 RM SQ / Mass	2.17 (0.50)	2.23 (0.34)	0.307	0.764
Baseline 1 RM BP (kg)	47.2 (9.3)	51.2 (9.3)	0.840	0.416
1 RM BP / Mass	0.76 (0.20)	0.80 (0.15)	0.386	0.706

NA = not applicable

Training Protocol

Both DUP and SUP groups performed the same number of training sessions (6), sets (120), and weekly and total repetitions (280 and 840). Although training intensity was varied on a daily basis for DUP and within the training session for SUP, mean training intensity was the same at the end of training. Total training volume for all exercises, as well as combined squat (SQ) and bench press (BP) training volumes, were analysed. Analysis performed on all-exercise and BP-SQ training volumes produced similar results. Thus, only all-exercise training volume will be reported. Mean comparisons indicated that the total training volumes (repetitions x mass lifted) did not differ significantly between groups ($t_{13} = 1.213$, $p = 0.247$), with DUP achieving 38.15 x 10^3 kg (± 5.17 x 10^3 kg) and SUP achieving 41.23 x 10^3 kg (± 4.62 x 10^3 kg). There were also no group-by-week differences in volume ($F_{2, 26} = 1.545$, $p = 0.232$), but both training groups increased their pooled training volumes significantly from week to week ($F_{2, 26} = 12.683$, $p = 0.0005$).

Body Mass and Limb Girth

There were no significant changes in body mass during the experimental period for both training groups (DUP: 63.62 ± 10.44 kg to 63.59 ± 10.65 kg; SUP: 65.77 ± 14.99 kg to 66.07 ± 14.90 kg). Similarly, there were no significant differences in mid-arm girth between the two groups of participants pre- and post-test (DUP: 28.4 ± 2.2 cm to 28.3 ± 2.2 cm; SUP: 28.9 ± 3.0 cm to 28.7 ± 3.2 cm). There was however, a significant group-by-test interaction for mid-thigh girth ($F_{1,\ 13}$ = 5.733, p = 0.032), indicating differential changes in mid-thigh girth scores pre- to post-test (DUP: 55.2 ± 4.2 cm to 54.8 ± 4.2 cm; SUP: 55.6 ± 6.2 cm to 56.1 ± 6.4 cm). In spite of the significant interaction effect, no other significant main effects were observed. Dependent *t*-tests on each training group found that while the DUP group observed a slight decrease in mid-thigh girth, the SUP obtained a pre- to post-test increase, with both *t* values approaching significance (DUP: t_7 = 1.793, p = 0.116; SUP: t_6 = 1.622, p = 0.156). Mean mid-thigh girth scores are illustrated in Figure 1.

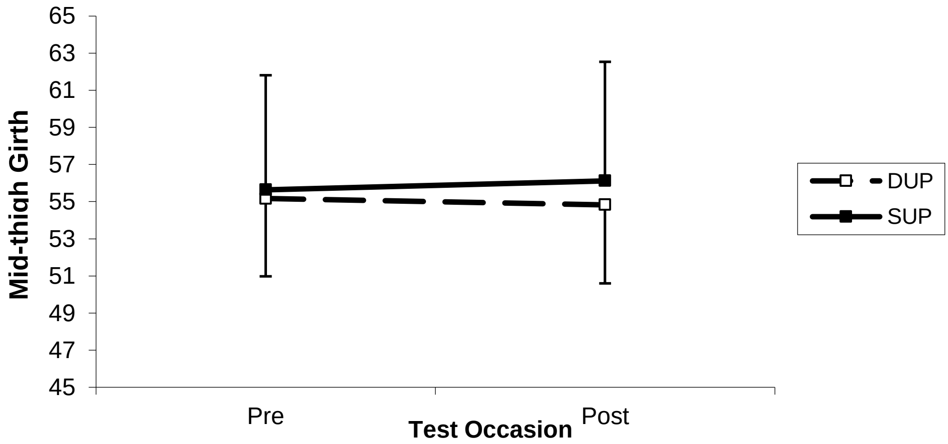

Figure 1: Mid-thigh means at pre- and post-test for the daily undulating periodisation (DUP) and session undulating periodisation (SUP) groups during the 3-wk maintenance phase. Results represent mean ± SD.

Maximal Dynamic Strength

Changes in upper- and lower-body maximal strength are presented in Figure 2. Changes in strength indices (relative strength) were found to be similar to absolute strength changes, and are not reported. There were neither significant group-by-test interactions for both the 1 RM BP and SQ (BP: $F_{1,\ 13}$ = 0.266, p = 0.614; SQ: $F_{1,\ 13}$ = 0.016, p = 0.901), nor significant between-group main effects (BP: $F_{1,13}$ = 0.630, p = 0.441; SQ: $F_{1,13}$ = 0.644, p = 0.437). When both groups were collapsed, pooled data obtained a significant main effect for test occasion for the upper body and approached significance for the lower body (BP: $F_{1,13}$ = 6.346, p = 0.025; SQ: $F_{1,13}$ = 2.721, p = 0.123). Both groups increased upper body strength (DUP 6.0 %, SUP 3.7 %), and obtained minimal changes in lower body strength (DUP 1.1 %, SUP 0.9 %). The larger increments observed in the upper body compared with the lower body is confirmed by effect sizes (BP: DUP ES = 0.3, SUP ES = 0.2; SQ: DUP ES = 0.07, SUP ES = 0.06).

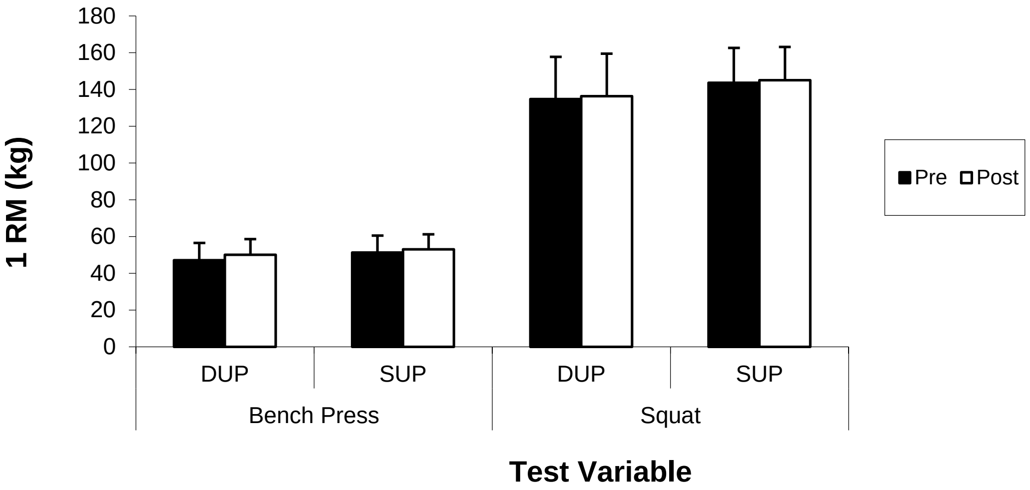

Figure 2: One-repetition maximum pre- to post-test comparisons in the bench press and the squat for the daily undulating periodisation (DUP) and session undulating periodisation (SUP) groups during the 3-wk maintenance phase. Columns and error bars represent mean ± SD.

BPT and CMJ

Both relative loads (30 % of 1 RM) and absolute loads (30 % of 1 RM used during baseline testing of the prior training programme) were utilised during the BPT and CMJ exercises to obtain scores for average mechanical power output and maximum jump/throw height of the barbell. Pre- and post-test scores for both training groups are presented in Table 4. Results indicate that there were neither significant differences between groups, nor significant group-by-test interactions over the training period for both BPT and CMJ power using relative or absolute loads. When data from both groups were pooled, there was no significant pre- to post-test change in average BPT power, but average CMJ power decreased during the 3-wk maintenance phase (relative load: $p = 0.050$, absolute load: $p = 0.016$). For the BPT, similar effect sizes (relative load: DUP ES = - 0.04, SUP ES = - 0.10; absolute load: DUP ES = 0.15, SUP ES = -0.06) and percentage changes (relative load: DUP = -0.6 %, SUP = -1.6 %; absolute load: DUP = 2.6 %, SUP = -1.1 %) were observed between pre- and post-test. Examination of effect sizes (relative load: DUP ES = - 0.14, SUP ES = - 0.36; absolute load: DUP ES = -0.19, SUP ES = -0.42) and percentages (relative load: DUP = -2.9 %, SUP = -7.56 %; absolute load: DUP = -3.3 %, SUP = -7.4 %) reinforced the decrease in power during the CMJ. Height of the barbell during CMJ did not record any significant differences between groups or tests. As relative loads were based on 1 RM scores, the loads used for BPT changed according to changes in maximal strength. Relative loads for BPT increased by 5.7 % for DUP and 3.4 % for SUP, while loads for CMJ remained similar.

Table 4: Average mechanical power, barbell height and average barbell loads utilised during BPT and CMJ at pre- and post-test occasions for the daily undulating periodisation (DUP) and session undulating periodisation (SUP) groups. All values are mean ± SD.

	DUP		SUP	
Variables	Pretest	Posttest	Pretest	Posttest
Average power (W):				
BPT 30 % 1 RM BP	221.3 ± 35.2	220.0 ± 38.0	224.3 ± 35.8	220.8 ± 28.5
BPT absolute load	220.2 ± 34.6	226.0 ± 36.9	225.6 ± 41.7	223.2 ± 31.8
CMJ 30 % 1 RM SQ	1061.5 ± 201.8	1030.3 ± 183.1	1045.6 ± 232.3	966.6 ± 225.6
CMJ absolute load	1080.7 ± 150.9	1045.2 ± 190.8	1074.2 ± 225.7	995.1 ± 217.8
Barbell height (m):				
Height of throw (30 % 1 RM)	0.53 ± 0.12	0.51 ± 0.14	0.44 ± 0.07	0.43 ± 0.08
Height of throw (absolute load)	0.69 ± 0.15	0.71 ± 0.15	0.59 ± 0.09	0.58 ± 0.10
Height of jump (30 % 1 RM)	0.36 ± 0.05	0.34 ± 0.04	0.32 ± 0.04	0.34 ± 0.05
Height of jump (absolute load)	0.47 ± 0.09	0.46 ± 0.11	0.42 ± 0.06	0.45 ± 0.09
Barbell loads (kg):				
BPT 30 % 1 RM BP	14.3 ± 3.1	15.1 ± 2.8	15.5 ± 2.7	16.1 ± 2.4
BPT absolute load	11.4 ± 2.2	11.4 ± 2.2	12.7 ± 2.6	12.7 ± 2.6
CMJ 30 % 1 RM SQ	40.6 ± 6.8	40.8 ± 7.1	43.7 ± 5.6	44.0 ± 5.3
CMJ absolute load	33.1 ± 7.7	33.1 ± 7.7	35.9 ± 5.3	35.9 ± 5.3

Discussion

Maintaining strength and power is important for many sports as cessation of resistance training can result in a decline of these strength qualities (Issurin, 2010). The present results suggest that both DUP and SUP programmes were equally effective in maintaining strength, power and muscle hypertrophy through a short (3-wk) periodised maintenance phase. It appears that maintenance programmes with similar training volumes promote similar strength and power responses (Baker, 1998; Kok, Hamer, & Bishop, 2009), regardless of the manipulation of volume and intensity applied.

There were no differences in age, mass, height, or upper- and lower-body strength between the participants in the two programmes prior to commencing training. Body mass and arm girth remained unchanged in both groups through the maintenance period, but mid-thigh girths obtained a significant group-by-test interaction, with DUP showing a slight decrement while SUP had an increment. Post-hoc analyses however, did not reveal any between-group or between-test differences which suggest that the amount of change may be due to error normally associated with measurements of girth, or that the differences were not large enough to reach statistical significance. However, it seems likely that hypertrophic responses were maintained as previous studies that have assessed girth (DeRenne, Hetzler, Buxton, & Ho, 1996) and skinfold measurements (Hoffman & Kang, 2003) had reported no changes after maintenance training.

Both training programmes resulted in increases in upper- (4.8 % in 1 RM BP) and lower-body maximal strength (1.0 % in 1 RM SQ) pre- to post-test. However, it should be noted that pooled data showed a significant main effect for time only in the upper-body. Increases in strength after maintenance training were also reported in some previous studies (Hoffman & Kang, 2003; Hoffman, Wendell, Cooper, & Kang, 2003), but other studies reported decrements (Scheidner, Arnold, Martin, Bell, & Crocker, 1998). The inconsistency in the results may be due to concurrent aerobic training, or other activities that were performed in all three studies, which may have confounded strength and power responses (Leveritt, Abernethy, Barry, & Logan, 1999). Additionally, for the current study larger strength increases were found in the upper body, while the increments in the lower body were minimal for the present participants contrasting with earlier studies (Hoffman & Kang, 2003; Hoffman, Wendell, Cooper, & Kang, 2003) that obtained larger strength increases in the lower body compared with the upper body. A possible explanation is that while the present female participants were highly trained in their lower body (strength index = 2.2), their upper-body strength was only moderately strong (strength index = 0.8). Previous studies have suggested that stronger individuals with increased training experience have a reduced capacity for strength adaptations and improvements (Baker, 2001); that is, the greater the strength, the smaller the scope for improvement. It is possible that this premise applies not only to the individual, but also to parts of the body that are stronger. Thus, the participants from the present study achieved strength improvements in the weaker upper-body, while maintaining strength in the lower-body as it was better-trained.

Power training in this maintenance study was performed with loads approximating 40 % of 1 RM. This load was much lower than those used in previous studies (Baker, 2001; Hoffman & Kang, 2003; Hoffman, Wendell, Cooper, & Kang, 2003), which were more than 65 % of 1 RM. It could be that light loads performed quickly and explosively could improve force and velocity, and thus power, through the intention to perform movements forcefully and explosively (Behm & Sale, 1993). The results of this study showed that while upper-body power was maintained, with no differences between DUP and SUP, lower-body power decreased by approximately 5.4 % in both groups ($p \leq 0.05$). This differed from a study that found no changes in both upper- and lower-body power through a maintenance phase (Baker, 2001). It may be that the total volume performed or the training frequency and intensity was inadequate for maintaining lower-body power in the present female participants. Another possible explanation for the discrepancy in results between studies may be that the participants in the previous maintenance studies (Baker, 2001; Hoffman & Kang, 2003; Hoffman, Wendell, Cooper, & Kang, 2003) also performed other modes of training (energy system, technical and tactical) which may provide additional stimulus for power maintenance while the present participants only performed the assigned training.

Most previous maintenance studies have examined the changes observed in strength (DeRenne, Hetzler, Buxton, & Ho, 1996; Hoffman & Kang, 2003; Hoffman, Wendell, Cooper, & Kang, 2003), with few researchers observing changes in power (Baker, 1998; Baker, 2001). A comparison of power output scores between the trained women from the present study with trained men (Baker, 2001) found that trained women could produce only approximately 38.7 % and 59.2 % respectively of the upper- and lower-body power scores produced by trained men. These sex discrepancies in power output have been previously discussed (Fleck & Kraemer, 2003) and it was noted that on average, women have approximately two-thirds of the power output of men, and that these differences are observed even in competitive male and female weight-lifters. Differences in upper-body power are especially large, probably due to sex-related differences in upper-body skeletal frame size and the lower levels of fat-free mass found in the upper body of women, which are associated with lesser leverage advantage and smaller muscle mass. The present study also detailed participants maintaining their lower-body strength, but obtaining decrements in lower-body power. This suggests an uncoupling of strength and power. These differences should only be used to stimulate further research on more effective modes to help women athletes achieve their genetic potential, rather than to accept that the present results as unavoidable.

Conclusion

In conclusion, the main finding of the present study was that the two forms of periodised maintenance training utilised in the study were able to maintain upper-body strength and power adequately across a 3-wk phase in resistance-trained women. Lower-body strength was similarly retained, but there was a small but significant decrement in average mechanical power. As both protocols employed a similar total volume (workload) and observed similar changes, it may be that the manipulation of volume and intensity is less important than the amount of work performed across the training period in maintaining strength and power. Strength increments are still possible during maintenance training, but appear limited to areas that are less developed initially. Future research into the use of light-load power training may need to observe a team of female athletes through an entire competitive phase in order to examine the interplay between the current maintenance programme and the additional stimulus from match play and technical/tactical training. Additional studies may also be needed to examine if trained women need to train for power with higher percentages of 1 RM for the lower body to prevent the reported decrease in power from occurring.

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