International Journal of Sports Physiology and Performance, (Ahead of Print)
https://doi.org/10.1123/ijspp.2019-0926

Human Kinetics
ORIGINAL INVESTIGATION

Q1

Self-Selecting the Number of Repetitions in Potentiation Protocols Enhances Jumping Performance

Antonio Dello Iacono, Marco Beato, and Israel Halperin

Purpose: To investigate whether providing athletes with a choice regarding the number of repetitions to complete in a potentiation protocol would enhance jumping performance compared with protocols in which the number of repetitions is predetermined. ***Methods:*** Fifteen male basketball players completed 4 testing sessions separated by 72 hours. In the first session, individual optimum power loads in the barbell jump squat were determined. In the following 3 sessions, the athletes completed 3 sets of 3 potentiation protocols using optimum power load jump squats in a partly randomized order: (1) the traditional condition included 6 repetitions per set, (2) the self-selected condition included a choice regarding the number of repetitions to complete per set, and (3) the imposed condition included the same number of repetitions per set as the self-selected condition, but the number was imposed on the athletes beforehand. The jumping performance was determined as jump squat test height and measured using a force platform before, 30 seconds, 4 minutes, and 8 minutes after completing the protocols. ***Results:*** The self-selected condition led to superior jumping performance compared with the 2 other conditions across all post measures ($P < .05$; range: 0.3–1.3 cm). Compared with the traditional condition, the imposed condition led to superior jumping performance across all post measures (range: 0.2–0.45 cm), although not statistically significant at post 4 minutes and post 8 minutes. ***Conclusions:*** Choice provision concerning how many repetitions to complete in a potentiation protocol is a useful performance-enhancing strategy. Improved potentiation–fatigue ratio and motivational factors are sought to explain these effects.

Q2

Keywords: autonomy, ballistic exercises, choice provision, explosiveness

Q3

Postactivation performance enhancement (PAPE) refers to a short-term improvement in athletic tasks, such as jumping, sprinting, and throwing, induced by a previous conditioning activity.[1] The onset and magnitude of PAPE effects are influenced by a number of variables and their interactions[2]: primarily, the type,[3,4] volume, and intensity of the conditioning activity[5,6]; the rest interval between the conditioning activity and the subsequent athletic task[7]; and the individual characteristics of the performer, including gender, strength levels, and training background.[5,8,9] The interactions between these variables result in 2 concurrent responses arising from the PAPE protocols: muscular fatigue and potentiation.[2] At the completion of the conditioning activity, muscular fatigue outweighs potentiation effects, resulting in impaired performance. However, since fatigue dissipates at a faster rate than potentiation, the potentiation effects can be realized at some point during the recovery interval, which enhances performance.[1] The balance between fatigue and potentiation is of paramount importance for successful PAPE protocol implementation and, thus, a topic of intensive investigations.

Q4

A growing number of studies investigated protocols designed to optimize PAPE effects by manipulating PAPE-related variables. However, the vast majority of them are commonly designed using predetermined and nonpersonalized loads and volumes.[1,5] Accordingly, it can be assumed that such general routines could induce too much fatigue for some and underpotentiate others. Although mean effects can be observed and acted upon, a more individualized approach could optimize the relationship between fatigue and potentiation. In support of this rationale, 2 recent studies observed that PAPE effects can be enhanced by using optimal power load (OPL) in the conditioning activity exercise, tailored per participant based on individual mechanical profiles.[4,10] Although the OPL approach is unfolding as a successful strategy to individualize the load variable of PAPE protocols, a method that individualizes the volume component needs to be developed.

One viable strategy to individualize the volume in the conditioning activity of PAPE protocols is allowing participants to choose when to terminate a set based on their understanding of the task and its requirements. Allowing people to act autonomously by making choices is a powerful evidence-based coaching strategy.[11–17] Studies from exercise psychology and motor learning have shown that, by providing choices regarding exercise-related variables, participants improve motor learning,[12] report greater enjoyment and motivation,[13] and exhibit greater adherence levels to an exercise program.[14] Recently, the effects of choice provision have been also studied in relation to physical performance outcomes that require maximal force production.[15,18] For example, Halperin et al[16] reported that providing competitive kickboxers with choices regarding the order of the delivered punches led to immediate increases in punching impact forces and velocity. Although the underpinning mechanisms accounting for these effects are not fully agreed upon, neuroscience[17] and psychological research[19] point to motivational reasons being the main pathway explaining the performance-enhancing effects. In view of the accumulating evidence, investigating whether the choice provision strategy can be implemented in PAPE protocols is a worthwhile endeavor.

The aims of this study were 3-fold. First, we aimed to investigate whether providing athletes with a choice on how

Dello Iacono is with the School of Health and Life Sciences, University of the West of Scotland, Glasgow, Scotland, United Kingdom. Beato is with the School of Health and Sports Sciences, University of Suffolk, Ipswich, United Kingdom. Halperin is with the School of Public Health, Sackler Faculty of Medicine, Tel Aviv University, Tel Aviv, Israel; and the Sylvan Adams Sports Inst, Tel Aviv University, Tel Aviv, Israel. Dello Iacono (antonio.delloiacono@uws.ac.uk) is corresponding author.

Q5

many repetitions to complete in the conditioning activity would improve subsequent athletic performance compared with a traditional PAPE-inducing condition in which the volume is fixed. Second, assuming that the choice condition should enhance performance, we aimed to examine its underlying cause. That is, will performance improve due to the self-selected volume, leading to an enhanced fatigue–potentiation relationship, or will the fact that the participants will be allowed to choose and act autonomously increase their motivation and drive to complete the task in a superior manner? To an extent, it is possible to answer this question by including a third condition, in which the exact same volume used in the choice condition will be subsequently and unknowingly imposed on the participants. Hence, in a third condition, the participants will be repeating the exact same condition as the self-selected one, but with the volume being imposed by a researcher. For this, trained athletes will complete 3 PAPE protocols, using jump squats with OPL as the conditioning activity: traditional, self-selected, and imposed conditions, with the outcome being the squat jump (SJ) performance.

Methods

Subjects

A convenience sample of 15 male professional basketball players (age 24.3 [4.2] y; height 188.1 [5.2] cm; body mass 87.7 [7.3] kg) volunteered to participate in the study. The players had at least 5 years (range: 5–9) of high-level practice and 5 years (range: 5–9) of resistance-training experience. All subjects also had at least 2 years (range: 2–5) of resistance-training experience involving OPL methodologies. Written informed consent was obtained after the subjects received an oral explanation of the purpose, benefits, and potential risks of the study. All procedures were conducted in accordance with the Helsinki Declaration and approved by the institution's ethics committee.

Design

A randomized crossover design was used to compare the effects of 3 PAPE protocols implementing jump squats loaded with OPL as the conditioning activity but executed using different configurations, as follows: (1) traditional, in which the sets and repetitions completed were aligned with the contemporary PAP literature[3–6,8–10]; (2) self-selected, in which the subjects were allowed to choose the number of repetitions completed in each set; and (3) imposed, in which the number of repetitions completed matched those of the self-selected condition, but were imposed on the subjects prior to the beginning of the session, rather than self-selected during each set. The effects of the 3 protocols were compared on subsequent vertical jump performances assessed by the SJ test. One week prior the study commencement, the subjects completed 2 familiarization sessions, during which they were provided with an explanation of the study procedures and performed the PAPE protocol using the traditional configuration. Then, 3 experimental sessions were completed, each including a standardized warm-up; baseline SJ assessment; one of the 3 conditions; and an SJ reassessment after 30 seconds, 4 minutes, and 8 minutes of passive recovery (see Figure 1 for overview). The order in which the protocols were completed was counterbalanced and partially determined by block randomization (www.random.org) so that the imposed protocol always followed the self-selected condition. All subjects performed the 3 experimental trials within 2 weeks and with 72 to 96 hours apart from each other. The protocols were executed according to the standard procedures previously reported.[10]

OPL Assessment

One week prior to the familiarization sessions, the OPL in the jump squat exercise was assessed for each athlete. First, the subjects performed an 8-minute general warm-up, consisting of running drills and dynamic mobilization exercises. Then, jump squat warm-up sets with progressively heavier loads were performed. The same instructions recently described by Dello Iacono et al[10] were used for the jump squat execution. The OPL was assessed following the protocol described by Loturco et al[20] on a Smith machine (Technogym Equipment, Italy). The OPL was determined as the jump squat with the highest mean propulsive power values measured during the successive trials, and then used to design the PAPE protocols. The mean propulsive power measures were collected using a linear encoder (Chronojump, Barcelona, Spain) sampling at 1000 Hz and fixed to the bar of the Smith machine, and computed using the commercial software provided by the manufacturer in conjunction with the device. Finally, the body mass normalized mean propulsive power outputs (relative power in watts per kilogram) were used for data analysis purposes. The normalized mean propulsive power score measured during the OPL assessment was 9.6 (1.3) $W \cdot kg^{-1}$.

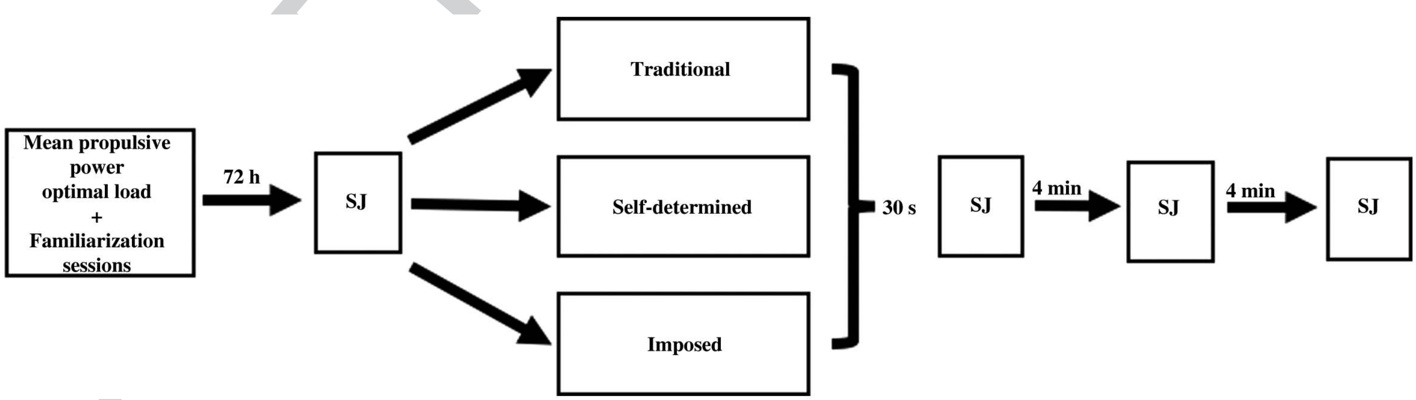

Figure 1 — Schematic representation of the study design. SJ indicates squat jump.

Vertical Jump Assessment

Vertical jump capability was assessed by an SJ test, following a standard protocol. The SJ's vertical ground reaction force (GRF) outputs were collected by stationary force plate (Kistler Biomechanics; Kistler, Winterthur, Switzerland). The sampling frequency was set at 500 Hz, and the signal was electronically processed and amplified by a Kistler amplifier (model no. 9681A; Kistler). The GRF data were used to define some key instants of the SJ, such as (1) start—defined as the instant at which the GRF went above a threshold value of 5% relative to the subject's body mass and (2) takeoff—defined as the instant at which the GRF went below the threshold value of 0 N. The vertical jump performance (in cm) was determined by the vertical velocity of the center of mass at takeoff, calculated by double integrating the vertical GRF through the impulse-momentum method.[21] Both the peak vertical GRF outputs (GRF_{peak}) and the relative vertical impulse determined from the force–time curves as the ratio between the total impulse produced during the SJ and the impulse due to body mass alone were collected. The subjects completed a baseline assessment consisting of 3 SJs (the best result used for the analysis), with an approximate 45-second rest in-between, while only a single SJ trial was repeated per each post-PAPE time point. A single researcher administered all the tests, thus minimizing potential effects due to the provided instructions.

Postactivation Performance Enhancement Protocols

All 3 PAPE protocols consisted of 3 sets of jump squats loaded with OPL. In the traditional protocol, the subjects completed 6 repetitions across the 3 sets. In the self-selected protocol, the subjects completed as many repetitions as they felt fit to minimize fatigue and maximize subsequent performance in each set. The number of completed repetitions was determined during each ongoing set. In the imposed protocol, the subjects completed the same number of repetitions as in the self-selected condition, but this time absent of choice. That is, the subjects were told how many repetitions they would need to complete by the researcher, and unknowingly to them, the numbers were identical to those they had completed in the self-selected condition. The rest period between sets in all protocols was 2 minutes. The subjects were asked to assume the same position as the one described for the OPL assessment procedures and instructed to focus on moving the bar as fast and as forcefully as possible by promoting an external focus of attention to elicit the greatest mechanical outputs.[22]

Statistical Analysis

All data are presented as means (SDs) and confidence interval (95% CI). Normality of the absolute data was investigated using the Shapiro–Wilk test, and skewness and kurtosis values smaller than 2 served as indication of normality.[23] The intraday reliability of the 3 baseline SJs on days 2, 3, and 4 was examined using the coefficient of variation (both absolute and percent). A coefficient of variation <5% is considered a cutoff value for high reliability.[24] The interday reliability of the highest baseline SJs on days 2, 3, and 4 was assessed by calculating the intraclass correlation coefficient (3,1). Values <.5, between .5 and .75, between .75 and .9, and >.9 were interpreted as indicative of poor, moderate, good, and excellent reliability, respectively.

To compare the effects between the PAPE protocols, a 2-way repeated-measures analysis of variance (ANOVA) of the absolute scores across all time points was used (3 conditions × 4 time points [baseline, post 30 s, post 4 min, and post 8 min]). This analysis was conducted for the following variables: jump height, impulse, and GRF_{peak}. In addition, the primary outcome, SJ height, was also analyzed by comparing the change scores of the post–pre differences between conditions. That is, the posttest values of each participant were subtracted from the baseline values within a given condition (eg, post 30 s – baseline). Then, these differences were compared between conditions using the 2-way repeated-measures ANOVA (3 conditions × 3 time points [post 30 s, post 4 min, and post 8 min]). This allowed for an examination of the differences between conditions, while also accounting for baseline differences. The individual athletes' power outputs monitored during each PAPE protocol were expressed as the percentage of the relative mean propulsive power recorded during the OPL assessment to provide an estimate of fatigue elicited by the 3 protocols. Differences between conditions were analyzed using a 1-way ANOVA. Significance was at $P < .05$. The 95% CIs are reported alongside the P values to allow for a better qualitative interpretation of the data.[25,26] If significant main effects or interactions were identified, then post hoc analyses were conducted using the Holm–Bonferroni correction for the P values and CI.[27] Finally, differences in the repetitions completed between the 3 conditions were analyzed using a 1-way nonparametric ANOVA (Kruskal–Wallis H test) due to the violation of the normality distribution assumption. All statistical analyses were conducted using Jamovi (version 1.0.5.0) and Excel sheets.

Results

The duration of the protocols, including the rest intervals and duration of the sets, was 5 minutes for all the conditions. All data presented normal distribution, except for the conditioning volumes (number of sets by number of repetitions) of the 3 experimental protocols. The absolute scores of the individual intraday variation between the 3 baseline SJs on days 2, 3, and 4 were ≥0.4 cm; the coefficient of variation percentages on days 2 and 3 of the intraday SJs were ≥0.8%; and the intraclass correlation coefficient scores between the highest baseline SJs on days 2, 3, and 4 were .95. These results demonstrate high interday and intraday reliability.

First, a significant main effect for time was observed for absolute jump height ($F_{6,84} = 30.7$, $P < .001$). Across all conditions, a similar pattern emerged, with jump height reduced by 1 cm (95% CI, 0.7 to 1.2; $P < .001$) at post 30 seconds compared with the baseline, but then improved by 1.7 cm (95% CI, 1.4 to 1.9; $P < .001$) and 1.8 cm (95% CI, 1.6 to 2.0; $P < .001$) at post 4 minutes and post 8 minutes, respectively, compared with the baseline. Second, statistically significant interactions were identified between conditions and time for absolute jump height ($F_{6,84} = 30.7$, $P < .001$), impulse ($F_{6,84} = 31.5$, $P < .001$), GRF_{peak} ($F_{3,38} = 12.9$, $P < .001$), and for the change scores in SJ height ($F_{3,45} = 4.2$, $P = .006$), all showing that the self-selected condition led to more favorable responses, compared with the traditional and imposed conditions, and that the imposed condition tended to lead to more favorable responds compared with the traditional (see Table 1 for descriptive statistics, corrected P values, and 95% CI). The Kruskal–Wallis H test revealed significant differences for conditioning volumes between both the self-selected and imposed conditions and the traditional one ($\chi^2 = 31.3$, $P < .001$). The number of repetitions completed during

Table 1 Descriptive (Mean [SD]) and Inferential (95% CI and *P* values) Statistics of All Variables, Across All Time Points, for All Conditions

	Time points			
	Baseline	**Post 30 s**	**Post 4 min**	**Post 8 min**
SJ absolute values, cm				
Traditional	45 (7.8)	43.4 (7.6)	46.1 (7.8)	46.2 (7.9)
Self-determined	44.7 (8.1)	44.3 (8)	47.1 (8.5)	47.5 (8.5)
Imposed	44.8 (7.4)	43.8 (7.5)	46.3 (7.6)	46.4 (7.7)
SJ change scores values, posttest–pretest values				
Traditional		−1.62 (0.5)	1.15 (0.26)	1.21 (0.24)
Self-determined		−0.39 (0.25)	2.38 (0.48)	2.73 (0.59)
Imposed		−1.01 (0.35)	1.49 (0.44)	1.58 (0.41)
SJ mean difference				
Traditional vs self-determined		−0.97 (−1.83 to −0.1), *P* = .021	−0.96 (−1.84 to −0.09), *P* = .024	−1.25 (−2.2 to −0.31), *P* = .008
Traditional vs imposed		−0.45 (−0.82 to −0.08), *P* = .008	−0.19 (−0.42 to 0.04), *P* = .103	−0.21 (−0.51 to 0.09), *P* = .228
Self-determined vs imposed		0.51 (−0.2 to 1.22), *P* = .188	0.78 (−0.21 to 1.76), *P* = .16	1.04 (0.05 to 2.02), *P* = .035
SJ change scores between conditions, cm				
Traditional vs self-determined		−1.24 (−0.81 to −1.66), *P* = .006	−1.21 (−1.15 to −1.27), *P* = .007	−1.51 (−1.02 to −1.99), *P* = .008
Traditional vs imposed		−0.62 (−0.27 to −0.97), *P* = .027	−0.33 (−0.15 to −0.51), *P* = .002	−0.37 (−0.14 to −0.6), *P* = .002
Self-determined vs imposed		0.62 (0.28 to 0.96), *P* = .004	0.88 (0.57 to 1.19), *P* = .004	1.14 (0.72 to 1.56), *P* = .005
GRF_{peak} absolute values, N				
Traditional	1585 (195)	1523 (190)	1630 (192)	1636 (194)
Self-determined	1590 (194)	1568 (191)	1687 (194)	1699 (193)
Imposed	1586 (203)	1549 (198)	1641 (209)	1648 (208)
GRF_{peak} mean difference				
Traditional vs self-determined		−45.2 (−67.6 to −22.9), *P* = .008	−57.6 (−88.4 to −26.8), *P* = .007	−62.9 (−100 to −25.6), *P* = .006
Traditional vs imposed		−25.4 (−52.1 to 1.4), *P* = .068	−11 (−33.6 to 14.6), *P* = .602	−11.6 (−36.7 to 13.6), *P* = .342
Self-determined vs imposed		19.9 (−7 to 46.7), *P* = .192	46.6 (4.5 to 87.7), *P* = .025	51.3 (3.8 to 98.9), *P* = .03
Impulse absolute values, $N \cdot s^{-1}$				
Traditional	2.58 (0.27)	2.48 (0.27)	2.64 (0.27)	2.65 (0.27)
Self-determined	2.59 (0.29)	2.56 (0.28)	2.72 (0.3)	2.75 (0.3)
Imposed	2.54 (0.21)	2.48 (0.21)	2.63 (0.21)	2.63 (0.21)
Impulse mean difference				
Traditional vs self-determined		−0.08 (−0.14 to −0.02), *P* = .063	−0.08 (−0.15 to −0.02), *P* = .006	−0.1 (−0.04 to −0.16), *P* = .008
Traditional vs imposed		0 (−0.04 to 0.03), *P* = .889	0.01 (−0.04 to 0.06), *P* = .998	0.01 (−0.04 to 0.07), *P* = .999
Self-determined vs imposed		0.08 (0.11 to 0.14), *P* = .016	0.1 (0.21 to 0.17), *P* = .01	0.11 (0.03 to 0.23), *P* = .007

Abbreviations: CI, confidence interval; GRF_{peak}, peak ground reaction force; SJ, squat jump.

the self-selected and the matched imposed protocols was 13.4 (0.98) and resulted in the following set configuration: 3 sets of 4.9 (0.26), 4.5 (0.52), and 3.9 (0.48).

Discussion

In this study, we examined whether providing subjects with a choice regarding the number of repetitions completed during a PAPE protocol would enhance vertical jump performance. The subjects completed 3 PAPE protocols: traditional, in which the number of repetitions in the conditioning activity was fixed; self-determined, in which the number of repetitions in the conditioning activity was self-selected; imposed, in which the number of repetitions matched the self-selected condition, but was imposed by a researcher unknowingly to the subjects. Across all 3 conditions, comparable time-course effects relative to the baseline were found, with initial reductions in SJ heights at post 30 seconds, followed by enhancements at post 4 minutes and post 8 minutes. However, differences between conditions were observed. First, compared with the 2 other conditions, the self-selected protocol led to superior performance across all post measures. Second, the imposed-condition-enhanced performance compared with the traditional condition. These findings have practical applications and can be largely explained by mechanical and motivational pathways.

The time-course effects induced by all PAPE protocols are consistent with the PAPE literature[2,4,6,9,10] reporting transitional fatigue at PAPE protocol completion, followed by potentiation after approximately 4 minutes of rest. The superior jumping performance observed in the self-selected condition, and partly in the imposed condition, can be explained by the individually

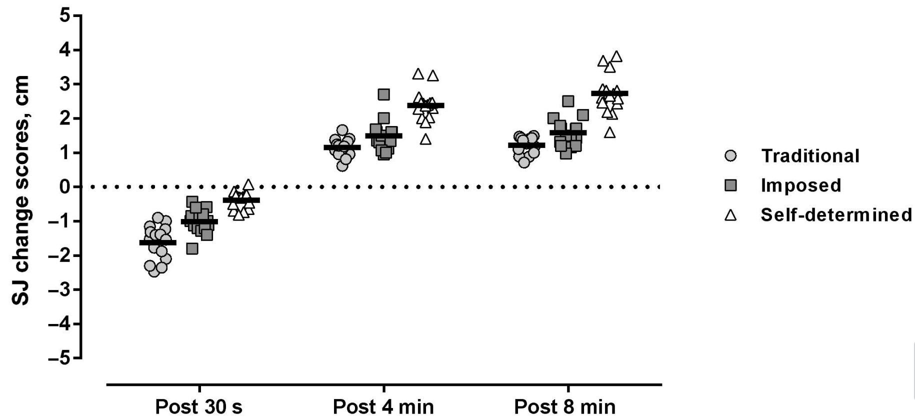

Figure 2 — The change scores in the 3 PAPE conditions relative to baseline performance represented by the dashed horizontal line. Dots, squares, and triangles denote individual scores. PAPE indicates postactivation performance enhancement; SJ, squat jump.

selected repetitions, which led to a more favorable fatigue–potentiation balance (Figure 2). This assumption is supported by 2 main observations. First, higher relative mean propulsive power values were observed during the self-selected protocol compared with both the traditional and imposed conditions (5.7% and 3.5%, respectively). Second, advantageous mechanical responses were associated to the SJ at the posttests following the self-determined protocol (Table 1). Specifically, the subjects were able to generate greater impulse outputs that, coupled with higher GRF_{peak}, indicate enhanced neuromuscular efficacy.[28] Hence, in view of the mechanistic perspective, it seems that the subjects were able to identify the number of repetitions required to elicit a better relationship between fatigue and potentiation. This is in contrast to the traditional condition, designed with a fixed number of repetitions, which does not allow for individual consideration of this balance. While a fixed number of repetitions in PAPE protocols may lead to enhanced performance at the group level, this strategy fails to account for ongoing and unfolding individual abilities that may fluctuate between and within individuals on a daily and even momentary basis.

Whereas the mechanical perspective can assist in explaining the differences between the self-selected and imposed conditions to the traditional condition, it cannot explain the differences between the former two. Since subjects under both conditions completed the same exact protocol, the superiority of the self-selected condition is likely the result of motivational aspects stemming from the subject's ability to choose. According to established psychological theories,[19,29] people strive to act autonomously by exerting control over their behaviors, environments, and goals. Granting people choice options increases the perception of autonomy and motivation to perform.[17,19,29,30] Research from a broad range of disciplines, including educational, workplace, health, and human movement domains, shows that choice provision is effective in improving a wide range of outcomes.[29,31,32] Whereas, in human movement sciences, choice provision has been mostly studied in the motor learning domain,[19] recent studies report that choice provision can also enhance acute physical performance.[15,16,30] For example, Halperin et al[16] reported that competitive kickboxers punched 3% to 10% harder and 6% to 11% faster when granted a choice about the order of punches to be delivered, compared with a condition in which the punch order was determined by a coach. Confirming these effects, Iwatsuki et al[15] reported that maximal handgrip strength was better maintained when recreationally trained subjects choose the order of the hands in which the contractions were completed (dominant vs nondominant). Such findings suggest that choice provision can positively affect immediate physical performance. The results of the current study are aligned with these findings and also support the use of autonomy-supportive strategies to acutely improve athletic performance.

This study has a number of limitations worthy of discussion. First, the study design was not fully randomized, considering that the imposed condition always followed the self-determined one. Therefore, an order effect inherent to this sequence may have somehow affected the results. Second, we did not conduct a power analysis to determine the sample size. For practical reasons, the sample was limited to a single team of athletes, which limits our ability to generalize to other populations. To partly overcome the limitations associated with smaller sample sizes, we implemented a within-subject design and controlled for a large number of confounding variables, such as diet, time of day, baseline warm-up, and more. Third, due to logistical constraints, the potentiation effects of the 3 protocols were investigated only on vertical jump capability, which was assessed in a lab-based environment. This fact narrows the ability to generalize the results from this study to more representative situations involving jumps during a basketball game. Future studies are warranted to investigate whether granting athletes with more choices, such as the conditioning activity type, conditioning activity load, protocol configuration, and rest interval, may lead to comparable or even better PAPE effects.

Practical Applications

Coaches should consider granting athletes with individual choices about the training volumes to be used for PAPE protocols aimed at enhancing vertical jump performance. Choice provision seems to exploit the PAPE effects by increasing the motivational drive, by reducing fatigue, and by enhancing the mechanical responses underpinning jumping performance. In view of the performance augmentations observed in this study, coupled with the broad supporting research, choice provision coaching strategies should likely be used more often and more explicitly by strength and conditioning coaches.

Conclusions

We found that allowing athletes to choose how many repetitions to complete during a PAPE protocol led to greater potentiation effects compared with 2 other conditions. The first was a traditional PAPE condition, in which the volume was fixed, and the second was a matched repetition condition, in which the subjects completed the same number of repetitions as they had done in the choice condition, but with the repetition number imposed by the researcher. This superior performance under the choice condition is likely due to enhanced motivation stemming from the subjects' ability to choose and by optimizing the fatigue–potentiating relationship within sets. These results point to the importance of individualized prescription approaches in PAPE protocols, with choice provision being one strategy to achieve this goal.

References

1. Blazevich AJ, Babault N. Post-activation Potentiation (PAP) versus Post-activation Performance Enhancement (PAPE) in humans: historical perspective, underlying mechanisms, and current issues. *Front Physiol*. 2019;10:1359. PubMed ID: 31736781 doi:10.3389/fphys.2019.01359
2. Tillin NA, Bishop D. Factors modulating post-activation potentiation and its effect on performance of subsequent explosive activities. *Sports Med*. 2009;39(2):147–166. PubMed ID: 19203135 doi:10.2165/00007256-200939020-00004
3. Dello Iacono A, Padulo J, Seitz LD. Loaded hip thrust-based PAP protocol effects on acceleration and sprint performance of handball players. *J Sports Sci*. 2018;36(11):1269–1276. PubMed ID: 28873044 doi:10.1080/02640414.2017.1374657
4. Dello Iacono A, Seitz LB. Hip thrust-based PAP effects on sprint performance of soccer players: heavy-loaded versus optimum-power development protocols. *J Sports Sci*. 2018;36(20):2375–2382. PubMed ID: 29595081
5. Wilson JM, Duncan NM, Marin PJ, et al. Meta-analysis of post-activation potentiation and power: effects of conditioning activity, volume, gender, rest periods, and training status. *J Strength Cond Res*. 2013;27(3):854–859. PubMed ID: 22580978 doi:10.1519/JSC.0b013e31825c2bdb
6. Dello Iacono A, Martone D, Padulo J. Acute effects of drop-jump protocols on explosive performances of elite handball players. *J Strength Cond Res*. 2016;30(11):3122–3133. PubMed ID: 26958786 doi:10.1519/JSC.0000000000001393
7. Dello Iacono A, Martone D, Milic M, Padulo J. Vertical- vs horizontal-oriented drop jump training: chronic effects on explosive performances of elite handball players. *J Strength Cond Res*. 2017;31(4):921–931. PubMed ID: 27398920 doi:10.1519/JSC.0000000000001555
8. McBride JM, Nimphius S, Erickson TM. The acute effects of heavy-load squats and loaded countermovement jumps on sprint performance. *J Strength Cond Res*. 2005;19(4):893–897. PubMed ID: 16287357
9. Seitz LB, Haff GG. Factors modulating post-activation potentiation of jump, sprint, throw, and upper-body ballistic performances: a systematic review with meta-analysis. *Sports Med*. 2016;46(2):231–240. PubMed ID: 26508319 doi:10.1007/s40279-015-0415-7
10. Dello Iacono A, Beato M, Halperin I. The effects of cluster-set and traditional-set postactivation potentiation protocols on vertical jump performance. *Int J Sports Physiol Perform*. 2019;1–6.
11. Halperin I, Wulf G, Vigotsky AD, Schoenfeld BJ, Behm DG. Autonomy: a missing ingredient of a successful program? *Strength Cond J*. 2018;40(4):18–25.
12. Wulf G, Iwatsuki T, Machin B, Kellogg J, Copeland C, Lewthwaite R. Lassoing skill through learner choice. *J Mot Behav*. 2018;50(3):285–292. PubMed ID: 28854061 doi:10.1080/00222895.2017.1341378
13. Lewthwaite R, Chiviacowsky S, Drews R, Wulf G. Choose to move: the motivational impact of autonomy support on motor learning. *Psychon Bull Rev*. 2015;22(5):1383–1388. PubMed ID: 25732095 doi:10.3758/s13423-015-0814-7
14. Silva MN, Markland D, Carraca EV, et al. Exercise autonomous motivation predicts 3-yr weight loss in women. *Med Sci Sports Exerc*. 2011;43(4):728–737. PubMed ID: 20689448 doi:10.1249/MSS.0b013e3181f3818f
15. Iwatsuki T, Abdollahipour R, Psotta R, Lewthwaite R, Wulf G. Autonomy facilitates repeated maximum force productions. *Hum Mov Sci*. 2017;55:264–268. PubMed ID: 28865313 doi:10.1016/j.humov.2017.08.016
16. Halperin I, Chapman DW, Martin DT, Lewthwaite R, Wulf G. Choices enhance punching performance of competitive kickboxers. *Psychol Res*. 2017;81(5):1051–1058. PubMed ID: 27465395 doi:10.1007/s00426-016-0790-1
17. Leotti LA, Delgado MR. The inherent reward of choice. *Psychol Sci*. 2011;22(10):1310–1318. PubMed ID: 21931157 doi:10.1177/0956797611417005
18. Halperin I, Chapman DW, Martin DT, Abbiss C, Wulf G. Coaching cues in amateur boxing: an analysis of ringside feedback provided between rounds of competition. *Psychol Sport Exerc*. 2016;25:44–50. doi:10.1016/j.psychsport.2016.04.003
19. Wulf G, Lewthwaite R. Optimizing performance through intrinsic motivation and attention for learning: the OPTIMAL theory of motor learning. *Psychon Bull Rev*. 2016;23(5):1382–1414. PubMed ID: 26833314 doi:10.3758/s13423-015-0999-9
20. Loturco I, Nakamura FY, Tricoli V, et al. Determining the optimum power load in jump squat using the mean propulsive velocity. *PLoS One*. 2015;10(10):e0140102. PubMed ID: 26444293 doi:10.1371/journal.pone.0140102
21. Moir GL. Three different methods of calculating vertical jump height from force platform data in men and women. *Meas Phys Educ Exerc Sci*. 2008;12(4):207–218. doi:10.1080/10913670802349766
22. Wulf G. Attentional focus and motor learning: a review of 15 years. *Int Rev Sport Exerc Psychol*. 2013;6(1):77–104. doi:10.1080/1750984X.2012.723728
23. Leech NL, Onwuegbuzie AJ. *A Call for Greater Use of Nonparametric Statistics*. 2002.
24. Hopkins WG. Measures of reliability in sports medicine and science. *Sports Med*. 2000;30(1):1–15. PubMed ID: 10907753 doi:10.2165/00007256-200030010-00001
25. Cumming G. The new statistics: why and how. *Psychol Sci*. 2014;25(1):7–29. PubMed ID: 24220629 doi:10.1177/0956797613504966
26. Dragicevic P. Fair statistical communication in HCI. In: *Modern Statistical Methods for HCI*. Springer; 2016:291–330.
27. Ludbrook J. Multiple inferences using confidence intervals. *Clin Exp Pharmacol Physiol*. 2000;27(3):212–215. PubMed ID: 10744350 doi:10.1046/j.1440-1681.2000.03223.x
28. Winter EM. Jumping: power or impulse? *Med Sci Sports Exerc*. 2005;37(3):523. doi:10.1249/01.MSS.0000155703.50713.26
29. Sanli EA, Patterson JT, Bray SR, Lee TD. Understanding self-controlled motor learning protocols through the self-determination theory. *Front Psychol*. 2012;3:611. PubMed ID: 23430980

30. Wulf G, Freitas HE, Tandy RD. Choosing to exercise more: small choices increase exercise engagement. *Psychol Sport Exerc*. 2014;15(3):268–271. doi:10.1016/j.psychsport.2014.01.007
31. Patall EA, Cooper H, Robinson JC. The effects of choice on intrinsic motivation and related outcomes: a meta-analysis of research findings. *Psychol Bull*. 2008;134(2):270–300. PubMed ID: 18298272 doi:10.1037/0033-2909.134.2.270
32. Teixeira PJ, Carraca EV, Markland D, Silva MN, Ryan RM. Exercise, physical activity, and self-determination theory: a systematic review. *Int J Behav Nutr Phys Act*. 2012;9(1):78. PubMed ID: 22726453 doi:10.1186/1479-5868-9-78

Queries

Q1. Please note that titles should generally not be full sentences. Please consider an edit to your title to avoid the full sentence.

Q2. In the sentence containing “imposed condition included the same number of repetitions . . .” please check and confirm the suggested changes.

Q3. As per journal style, repeats of words in article and journal title are not allowed in keywords. Hence, the keyword "jumping" was deleted.

Q4. Please check the edits to the sentence "The onset and . . ." and correct if necessary.

Q5. Please ensure author information is listed correctly here and within the byline.

Q6. US reviewer: Please check the sentence "That is, will . . . ."

Q7. In the sentence containing “That is, will performance improve . . .” please check and confirm the suggested changes.

Q8. In the sentence containing “That is, will performance improve due to . . .” please check and confirm the suggested change.

Q9. As per journal style, “mean ± SD” should be represented as “mean (SD).” Hence, the values are changed accordingly throughout the article. Please check and confirm.

Q10. Please mention the name of the institution’s ethics committee in the sentence "All procedures were . . . ."

Q11. In the sentence containing “Then, 3 experimental sessions were completed . . .” please check and confirm the suggested changes.

Q12. Please provide city name for the manufacturer "Technogym Equipment."

Q13. Please check if edits to the sentence "The normalized mean . . ." retain the intended meaning and correct if necessary.

Q14. In the sentence containing “vertical ground reaction force (GRF) outputs . . .” please check and confirm the suggested change.

Q15. Please check if the phrase "between .5 and .75, between .75 and .9" can be changed to "between .5 and .75, between .76 and .9."

Q16. In the sentence containing “while also accounting for baseline differences” please check and confirm the suggested changes.

Q17. Please provide manufacturer name and location (city, state [if USA], and country) details for "Jamovi" and "Excel sheets."

Q18. AMA style recommends that P values should be expressed to 2 digits to the right of the decimal point, unless $P < .01$. Consider editing P values throughout the paper to 2 digits to the right of the decimal point unless additional digits convey useful information.

Q19. Originally, reference citations were not in sequential order. Hence to maintain sequential order References were renumbered as per style. Please verify.

Q20. Please provide issue number for Ref. 1.

Q21. Please provide volume number and issue number if applicable for Ref. 10.

Q22. Please provide issue number if applicable for Ref. 15.

Q23. Please provide issue number if applicable for Ref. 18.

Q24. Please provide the complete details for Ref. 23.

Q25. Please provide editor(s) name and publisher location for Ref. 26.

Q26. Please provide issue number if applicable for Ref. 29.