A comparison between predetermined and self-selected approaches in resistance training: Effects on power performance and psychological outcomes among elite youth athletes

Kevin Watson [Equal first author, 1, 2] , **Israel Halperin** [Equal first author, 3, 4] , **Joan Aguilera-Castells** [5] , **Antonio Dello Iacono** [Corresp. 2]

1 Strength and Conditioning Department, Glasgow School of Sport, Glasgow, United Kingdom

2 School of Health and Life Sciences, University of the West of Scotland, Glasgow, United Kingdom

3 School of Public Health, Tel Aviv University, Tel Aviv, Israel

4 Sylvan Adams Institute, Tel Aviv, Israel

5 Faculty of Psychology, Education Sciences and Sport, Universitat Rámon Llull, Barcelona, Spain

Corresponding Author: Antonio Dello Iacono
Email address: antonio.delloiacono@uws.ac.uk

Background. The aim of this study was to investigate if choice over resistance training exercise order affects motor performance and psychological outcomes among elite youth hockey players. **Methods.** Seventeen elite hockey players (male, n = 14; female, n = 3, age: 15.1±1.1 years) participated in this study. In the first session, individual optimum power loads were calculated in the back squat, jump squat, bench press and bench throw exercises. Then, in four counterbalanced sessions, participants completed three sets of six repetitions in the same exercises loaded with their optimum power loads. In two sessions, athletes used a self-selected order of exercises, while in other two sessions the order was predetermined. Power outputs were estimated with a linear position transducer. Fatigue and enjoyment were measured during and after the sessions using standardized questionnaires. Repeated measures analyses of variance and a paired-sample t-test were used to compare the effects between conditions. **Results.** We observed trivial to small differences between conditions in power outputs (p≥0.07; ES≤0.21), fatigue (p≥0.42; ES≤0.33) and enjoyment (p=0.72; ES=0.05). **Conclusion.** Given the comparable effects between approaches, both can be used when coaching youth athletes. Self-selecting the order of exercises based on preferences is a feasible and practical coaching option when working with youth athletes.

1 **A comparison between predetermined and self-**
2 **selected approaches in resistance training: effects on**
3 **power performance and psychological outcomes**
4 **among elite youth athletes.**

7 Kevin Watson[1,2] *, Israel Halperin[3,4] *, Joan Aguilera-Castells[5], Antonio Dello Iacono[2]

9 [1] Strength and Conditioning Department, Glasgow School of Sport, Glasgow, United
10 Kingdom
11 [2] School of Health and Life Sciences, University of the West of Scotland, Glasgow,
12 United Kingdom
13 [3] School of Public Health, Tel Aviv University, Tel Aviv, Israel
14 [4] Sylvan Adams Sports Institute, Tel Aviv University, Tel Aviv, Israel
15 [5] Faculty of Psychology, Education Sciences and Sport Blanquerna, Ramon Llull
16 University, Barcelona, Spain

18 * equal first author

20 **Corresponding Author:**
21 Antonio Dello Iacono
22 Stephenson Place, G72 0LH, Hamilton, United Kingdom
23 Email address: antonio.delloiacono@uws.ac.uk

26

27

28

29

30

31

32

33

34

35

36

37 **Abstract**

38 **Background.** The aim of this study was to investigate if choice over resistance training
39 exercise order affects motor performance and psychological outcomes among elite
40 youth hockey players.

41 **Methods.** Seventeen elite hockey players (male, n = 14; female, n = 3, age: 15.1±1.1
42 years) participated in this study. In the first session, individual optimum power loads
43 were calculated in the back squat, jump squat, bench press and bench throw exercises.
44 Then, in four counterbalanced sessions, participants completed three sets of six
45 repetitions in the same exercises loaded with their optimum power loads. In two
46 sessions, athletes used a self-selected order of exercises, while in other two sessions
47 the order was predetermined. Power outputs were estimated with a linear position
48 transducer. Fatigue and enjoyment were measured during and after the sessions using
49 standardized questionnaires. Repeated measures analyses of variance and a paired-
50 sample t-test were used to compare the effects between conditions.

51 **Results.** We observed trivial to small differences between conditions in power outputs
52 (p≥0.07; ES≤0.21), fatigue (p≥0.42; ES≤0.33) and enjoyment (p=0.72; ES=0.05).

53 **Conclusion.** Given the comparable effects between approaches, both can be used
54 when coaching youth athletes. Self-selecting the order of exercises based on
55 preferences is a feasible and practical coaching option when working with youth
56 athletes.

57

58

59

60

61

62

63

64

65

66

67

68

69

70

71

72

73

Introduction

74 **Introduction**
75 Designing effective resistance training programs requires careful consideration of how
76 to manipulate the different variables such as training volume and intensity, exercises
77 selection and exercise order. Regarding the latter variable, research has shown that the
78 order of exercises can directly affect subsequent strength adaptations (Nunes et al.,
79 2020; Simao et al., 2012). Exercises completed early in a session can be executed with
80 higher external loads and superior efficacy due to the minimal concurrent and
81 detrimental effects of local fatigue (Nunes et al., 2020; Simao et al., 2012). The superior
82 peak and total force associated with exercises performed at the beginning of a session
83 can lead to greater gains in strength capabilities compared to programs in which the
84 same exercises are performed later (Nunes et al., 2020; Simao et al., 2012). While most
85 studies have focused on force production capabilities, given the intimate relationship
86 between force production and power development (Enoka & Duchateau, 2008),
87 exercise order can be expected to influence the latter in a similar fashion.
88 Consequently, resistance training programs are traditionally designed with the exercises
89 prescribed in a fixed and predetermined order before sessions initiation and depending
90 on the main training goals (Ratamess et al., 2009; Sands et al., 2012). Despite the clear
91 benefits of the predetermined approach, implementing it with large groups of athletes, in
92 confined spaces, or with limited equipment, may lead to a number of difficulties. Mainly,
93 athletes need to wait until a piece of equipment is free which may lead to boredom,
94 cooling down, and inefficient usage of time, all of which compromise the efficacy of the
95 session.
96   A possible alternative to the predetermined approach is the self-selected
97 approach, in which athletes are allowed to make choices concerning various resistance
98 training variables. Choices can include the selection of exercises (Rauch et al., 2020),
99 their order (Nunes et al., 2020; Simao et al., 2012) and number of repetitions completed
100 (Emanuel et al., 2020). A growing number of studies report superior or comparable
101 acute performance effects (Halperin et al., 2017; Iwatsuki et al., 2017) and long-term
102 adaptations (Colquhoun et al., 2017; McNamara & Stearne, 2010; Rauch et al., 2020)
103 following self-selected protocols compared to the predetermined approaches. In
104 addition to effective performance outcomes, the use of self-selected approaches in
105 resistance training has many benefits. First, allowing athletes to choose the order of
106 exercises can overcome logistical challenges associated with coaching large groups
107 with limited equipment. For example, rather than having all athletes wait in line to
108 complete the same exercise on the single piece of available equipment, athletes can
109 begin the session using different exercises. Second, having the freedom to make
110 choices enhances motor learning (Wulf & Lewthwaite, 2016) motivation to perform (Deci
111 & Ryan, 2000; Wulf & Lewthwaite, 2016), perception of well-being (Adie et al., 2012)
112 and the likelihood of adhering to a program (Silva et al., 2011). Hence, granting athletes

113 choice in exercise order has unique benefits that may, at times, outweigh the
114 physiological benefits associated with a predetermined exercise order.
115   In a recent review, Halperin at al. (2018) suggested that when adopting
116 autonomy-supportive strategies to plan strength and conditioning sessions, coaches
117 should consider the type, number, and range of choices, along with contextual factors
118 pertaining to the training environment and the coach-athlete relationship. While more
119 studies comparing the effects of self-selected and predetermined approaches in
120 strength and conditioning settings are being carried out (Colquhoun et al., 2017;
121 Emanuel et al., 2020; McNamara & Stearne, 20120; Rauch et al., 2020), to our
122 knowledge none have been conducted on youth athletes. Accordingly, the aim of this
123 study is to investigate the effects of choice provision over exercise order in strength and
124 conditioning sessions on acute power performance outcomes and subjective responses
125 of fatigue and enjoyment among youth athletes. Our main hypothesis was that granting
126 athletes with choice would enhance power performance outcomes, increase athletes'
127 enjoyment and reduce perceptions of fatigue.

128

129 Materials & Methods

130 Subjects

131 The planned sample size consisted of twenty elite academy hockey players. However,
132 fourteen participants (male, n = 11 and female n = 3) performed all four experimental
133 sessions, while three participants (male, n = 3) completed only two sessions, one for
134 each condition (See Table 1 for participants' characteristics). Two participants dropped
135 out due to injuries sustained during sport-specific activities and one participant withdrew
136 before completion of the study. Participants had at least 2 years (range: 2-9) experience
137 of high-level training in a youth academy and at least 1-year (range: 1-6) experience of
138 strength and conditioning training, especially in the four exercises used in this study.
139 However, athletes were mostly familiarized with the predetermined approach, and had
140 little to no experience with the self-selected approach prior to the time of the study
141 commencement. Written informed consent was obtained from the participants or their
142 legal representative after receiving a written and oral explanation of the purpose,
143 benefits and potential risks of the study. All procedures were conducted in accordance
144 with the Helsinki Declaration and approved by the ethics committee of the University of
145 the West of Scotland (IRB: 2019-8652).

146

147 ***Table 1 about here***

148

149 Design

150 A randomized crossover design (Fig. 1) was used to compare the power outputs and
151 subjective responses of fatigue and enjoyment during four resistance training sessions
152 implementing upper and lower body exercises: bench press, bench throw, back squat

153 and jump squat. Across sessions, the exercises were loaded with the same external
154 resistance – optimum power load (OPL) – but structured with different exercise orders:
155 (1) self-selected, in which participants chose their preferred order of exercises, (2)
156 predetermined, in which the order was imposed on the participants. Power outputs were
157 estimated using a linear position transducer. Subjective responses of fatigue and
158 enjoyment were collected using the rate of fatigue (ROF; Micklewright et al., 2017) and
159 the Physical Activity Enjoyment Scale (PACES; Teques et al., 2017) questionnaires,
160 respectively. Data was collected over a 3-week period in which participants completed
161 one OPL assessment session, and four experimental sessions. Specifically, participants
162 performed each of the experimental trials twice: two sessions with the self-selected
163 exercise order, and two other sessions with the predetermined exercise order. The
164 decision to adopt a repeated measures design in this study was two-fold. First, it
165 allowed collecting multiple data points from each participant which increased statistical
166 power. Second, the outputs of the two trials performed in each condition were compared
167 to investigate the reliability of the measures across the same condition. The order of the
168 experimental trials was counterbalanced and determined by block randomization.
169 Following the OPL assessment, participants also completed one familiarization session
170 for each condition to become acquainted with the experimental procedures. The
171 purpose of the study was kept somewhat vague so as not to bias the results (Halperin
172 et al., 2017). All sessions were completed in the same strength and conditioning training
173 facility, separated by at least 48-72 hours and supervised by two of the academy's
174 strength and conditioning coaches and two researchers. Participants were instructed to
175 avoid intense training 24 hours prior to each testing day, refrain from caffeine ingestion
176 for 24 hours prior to testing and instructed not to eat for 2-3 hours prior to each trial.
177
178 ***Fig. 1 about here***
179
180 Optimum power load assessment
181 In the first session, OPLs of the four exercises were determined for each participant. A
182 linear position transducer (Chronojump, Barcelona, Spain) sampling at 1000 Hz, fixed to
183 the bar at a perpendicular angle to the floor, and the commercial software provided by
184 the manufacturer for the device, were used to measure the velocity of the bar during the
185 four exercises. Criterion validity (i.e. comparison against a gold standard optical motion
186 capture system) as well as high reliability scores for the velocity derivative measures
187 collected with this device were recently reported by Pérez Castilla et al. (2019).
188 Participants performed a general warm up consisting of three sets of ten body-weight
189 squats followed by five squat jumps or three sets of ten press ups followed by five
190 plyometric press ups, before the lower body and upper body OLPs assessments,
191 respectively. Then, warm up sets with progressively heavier loads were performed in
192 each exercise. Standardized instructions were used for the exercises' execution (Dello

193 Iacono et al., 2020a). During the OPL assessment, each participant performed three
194 repetitions at maximum velocity for each progressive load. A starting load
195 corresponding to 40% of body mass, with 10kg and 5kg increments per set were used
196 in the back squat and bench press exercises, respectively. A starting load
197 corresponding to 20% of body mass, with 10kg and 5kg increments per set were used
198 in the jump squat and bench throw exercises, respectively. Loads were progressively
199 increased until a consistent decrement in velocity output was detected (Loturco et al.,
200 2015). This equated to approximately five testing sets per exercise (range: 4-6). The
201 OPLs were determined following the protocol described by Loturco et al. (2015) and
202 were identified as the absolute load resulting in the highest mean propulsive velocity
203 and the estimated corresponding power values observed during the trials. The individual
204 OPLs in each exercise (*Table 2*) were then used for the two experimental protocols.
205

206 ***Experimental protocols***
207 The order of the four exercises in the two conditions was determined in the following
208 manner. For the predetermined condition, the exercise order (back squat; jump squat;
209 bench press; bench throw) was established by consensus between two accredited
210 strength and conditioning coaches and two senior academic staff members in line with
211 an evidenced based practice approach (Ratamess et al., 2009; Sands et al., 2012). For
212 the self-selected condition, a month prior to the study commencement, each participant
213 was asked to indicate the preferred order of the four exercises. Additionally, one week
214 prior to the OPL assessment, each participant was given the choice to either confirm or
215 change the previously selected exercise order. Only one participant changed the
216 exercise order initially selected. Twelve different exercise orders were chosen by the
217 participants *(Fig. 2),* and only three participants selected the exact same order of the
218 predetermined condition. In each condition, participants performed the same
219 standardized warm up (see OPL assessment paragraph) followed by three sets of six
220 repetitions for each exercise loaded with the OPL in either the self-selected or
221 predetermined order, with two minutes rest between the sets and three minutes rest
222 between the exercises. Participants were asked to move the bar as fast and as
223 explosively as possible in all repetitions.
224

225 ****Fig. 2** about here***
226

227 ***Measures***
228 ***Power outputs***
229 Mean propulsive power (P_{mean}) outputs were estimated from the mean propulsive
230 velocity values monitored during the entire experimental trials with the same linear
231 position transducer and commercial software described above. P_{mean} outputs for each
232 exercise were then expressed as relative to body mass (W/kg).

233

Self-report measures

234 **Self-report measures**
235 At baseline and immediately after each exercise, the 11-point ROF Likert scale
236 (Micklewright et al., 2107) was used to assess subjective perceived non-local muscular
237 fatigue (Othman et al., 2017). The scale ranges from 0 ("not fatigued at all") to 10 ("total
238 fatigue and exhaustion-nothing left"). The question "How fatigued are you at the
239 moment?" was presented at the top of the scale. At the end of each protocol,
240 participants also completed the PACES questionnaire to rate their level of enjoyment
241 (Teques et al., 2017). Eight items were rated on a 7-point bipolar rating Likert scale
242 which ranged from 1 ("I do not agree at all") to 7 ("I totally agree"). The single-item
243 responses were tallied to calculate a summative score which was used for analysis.
244 Higher PACES scores reflect greater levels of enjoyment.

245

Statistical Analyses

247 All data are presented as means ± standard deviation (SD) and confidence interval
248 (95% CI). The Shapiro-Wilk test, with skewness and kurtosis values smaller than two
249 (Leech & Onwuegbuzie, 2002), served to investigate the normality distribution of the
250 absolute data. Reliability of the velocity outputs collected across the four sessions for
251 each exercise was assessed using the coefficient of variation (CV; percent score [%])
252 and the intra-class correlation coefficient ($ICC_{3,1}$). High reliability was determined as a
253 CV < 5% and an ICC > 0.70 (Cormack et al., 2008). We compared the effects between
254 the two conditions on power outputs using a 2 (condition: predetermined/self-selected)
255 $\times$ 4 (exercise: bench press/bench throw/back squat/squat jump) $\times$ 6 (repetition
256 number: 1 to 6) repeated-measures Analysis of Variance (ANOVA). For this purpose,
257 the P_{mean} outputs were averaged across the same repetition number (e.g., 1st to 6th
258 repetition) across the six sets (3 sets $\times$ 2 sessions) completed per exercise. The
259 average ROF responses per exercise were calculated between the two sessions
260 completed in each condition. Then, the effects on ROF responses between the two
261 conditions were compared using a 2 (condition: predetermined, self-selected) $\times$ 4
262 (exercise: back squat, squat jump, bench press, bench throw) repeated-measures
263 ANOVA. A paired-sample t-test was used to compare the effects on the PACES
264 responses which were also averaged across the two sessions completed in each
265 condition. The significance level was set at p<0.05. Post hoc analyses were conducted
266 using the Holm-Bonferroni correction for the p values and CIs (Dragicevic, 2016).
267 Finally, Cohen's *d* (Mean difference/SD average) effect sizes (ES) were determined to
268 provide qualitative descriptors of standardized effects and interpreted using the
269 following criteria: trivial <0.2, small 0.2–0.5, moderate 0.5–0.8 (Cohen, 1992). All
270 statistical analyses were conducted using Jamovi (version 1.2.9.0, Newcastle, UK).

271 We note that due to the fact that the reliability of the measures is a topic beyond the
272 primary aim of this study, the summary of the supplementary reliability analysis and a
273 brief discussion of the results are reported in the Data S1 file.
274
275 **Results**
276 All data were normally distributed. High reliability scores were observed consistently
277 across all exercise with all CVs < 5% and ICCs > 0.70 cut-off thresholds (See *Table 2*).
278 Individual data plots of power outputs for all thirty-six repetitions (2 sessions x 3 sets x 6
279 repetitions) performed during each exercise per condition are reported in *Fig. 3*. Average
280 power outputs values (i.e., 36 repetitions) in each exercise and in both conditions are
281 shown in *Fig. 4*. Descriptive, inferential and qualitative statistics of all variables across
282 the two conditions are reported in *Table 3*. No statistical differences were observed
283 between conditions ($F_{(1, 16)}$ = 4.05, p = 0.06) (See *Fig. 4*), interactions between conditions
284 and exercise ($F_{(3, 48)}$ = 0.16, all p ≥ 0.18), or between conditions and repetitions ($F_{(15, 240)}$
285 = 0.44, all p ≥ 0.08; all ES ≤ 0.21) on power outputs (See *Fig. 3*). Note that these findings
286 were accompanied by trivial to small effect sizes (See *Table 3*). No between-condition
287 statistical differences were found for the ROF responses in any of the exercises ($F_{(3, 48)}$ =
288 0.96, all p ≥ 0.41; all ES ≤ 0.33). Finally, the paired-sample t-test revealed no differences
289 between the two conditions on the PACES responses (p = 0.72; ES = 0.05).
290
291 ***Fig. 3, Fig. 4 and Tables 2 and 3 about here***
292
293 **Discussion**
294 We examined if providing choices over the order of exercises performed during strength
295 and conditioning training sessions would enhance acute power performance and
296 perceptions of fatigue and enjoyment as compared to a predetermined exercise order in
297 elite youth athletes. In contrast to our hypothesis, we found no statistical or practical
298 differences in power outputs, ROF and PACES scores between conditions.
299 The main findings of this study are aligned with some (Colquhoun et al., 2017; Emanuel
300 et al., 2020) but not most studies on this topic (Balaguer et al., 2012; Gonzalez et al.,
301 2016; Halperin et al., 2017; Kristiansen & Roberts, 2010). For example, competitive
302 boxers punched harder and faster when given a choice regarding the order of punches
303 delivered in a combination, compared to a predetermined order (Halperin et al., 2017).
304 Similarly, professional basketball players jumped higher after self-selecting the number
305 of repetitions to complete in a post-activation performance enhancement protocol,
306 compared to a fixed number of repetitions (Dello Iacono et al., 2020b). The discrepancy
307 between the results of the present study and those observing performance enhancing
308 effects may stem from a number of reasons.
309   First, some studies were completed in controlled laboratory environments,
310 whereas the current study was conducted in the athletes' natural training setting. Second,

311 the environment of this study was highly representative of real-life, but it came at the
312 expense of less control over various confounding variables (e.g., music, number of
313 persons in the room, peer-to-peer feedback), which may have reduced the effects of
314 choice provision (Halperin et al., 2015). Third, the timing of choice provision in the current
315 study was set weeks before it commenced for practical reasons. This is in contrast to
316 most other studies in which choice was provided on the same day, usually prior to the
317 motor task completion (Dello Iacono et al., 2020b; Emanuel et al., 2020; Halperin et al.,
318 2017. As a consequence, the time delay between the final choice of exercise order during
319 the self-selected condition and the event may have limited the positive mediating effects
320 of the choice. However, this speculation remains to be investigated. Finally, the
321 characteristics of the participants and the demands of their programs may have also
322 played a role: young, elite level athletes, who are required to participate in the strength
323 and conditioning sessions as part of their ongoing training routine. The very fact that the
324 sessions represented part of the athlete's regular and mandatory training schedules could
325 have also influenced the extent of the choice effects.

326   Given the similar power performance and psychological outcomes observed
327 between the conditions, both can be implemented interchangeably or even concurrently
328 in strength and conditioning sessions. This assumption is supported by the large range
329 of exercise orders selected by the athletes (*See Fig 2*). When the training goal in a given
330 session is to optimize power outputs, our findings indicate that allowing athletes to choose
331 the order of exercises can be effective in maintaining performances regardless of the
332 order the athletes ended up with during the sessions. These findings also have practical
333 importance. Given the trivial differences in power outputs, resistance training programs
334 based on the self-selected approach have an advantage as they are simpler to plan and
335 follow. This approach requires less constraints, facilitating session planning for the
336 coaches and session execution for the athletes. Indeed, the likelihood of athletes waiting
337 in line for equipment is minimized. Additionally, fostering independence among
338 developmental youth athletes through choice provision over training variables may lead
339 to positive psychological adaptions such as increased accountability and commitment to
340 the session goals. However, we note that these results should be treated with cation as
341 our study was conducted as an acute design and it is unclear if the same effects persist
342 over time.

343   This study has a few limitations worthy of discussion. For practical reasons, the
344 final sample size consisted only of seventeen subjects of which three completed two
345 rather than four experimental sessions. To partly overcome the limitations associated with
346 small sample sizes, we implemented a within-subject repeated-measures design
347 including double sessions per condition which led to the collection of more than 2000
348 repetitions that were subsequently analyzed. Participants were elite young team sport
349 athletes, so whether these findings can be generalized to other individuals (e.g. adult
350 athletes from either individual or team sports) require further research. Participants were

351 granted with only one choice regarding one training variable (i.e., the order of exercises).
352 This fact limits the generalizability of the results to other training scenarios including
353 different exercises, their configuration, intensity and volume. Future studies are warranted
354 to investigate whether granting athletes with other choices or combination of choices over
355 a few training variables may lead to effects similar to those observed in this study. Finally,
356 due to logistical constraints, participants had to pick and confirm their preferred order of
357 exercises one month and one week before the study commenced, respectively.
358 Therefore, it is worth investigating to what extent the timing of choice provision mediates
359 the associated effects, and whether the latter can be optimized with preferences
360 expressed more imminently to the performed tasks.

361

Conclusions

363 We found that sessions in which the order of exercises was either predetermined or
364 self-selected led to comparable power performances and psychological effects among
365 youth athletes. Thus, self-selecting the exercise order is a valid alternative to a
366 predetermined approach. These findings are of practical value as they suggest coaches
367 adopting self-selected strategies to individualize prescription in resistance training
368 practice based on individual preferences.

369

Acknowledgements

371 We would like to thank the academy's Sport Performance Manager for granting access
372 to the facilities and pupils, the Head Hockey Coach for his support in participant
373 recruitment, the Assistant Head of Strength and Conditioning for his support in
374 managing the experimental trials within the academy's S&C programme and the
375 participants.

376
377
378
379
380
381
382
383
384
385
386
387
388
389
390
391

392 **References**

393 Adie, J., Duda, J., & Ntoumanis, N. (2012). Perceived coach-autonomy support, basic need
394 satisfaction and the well- and ill-being of elite youth soccer players: A longitudinal investigation.
395 *Psychology of Sport and Exercis*e, 13(1), 51-59. DOI:
396 https://doi.org/10.1016/j.psychsport.2011.07.008
397
398 Balaguer, I., Gonzalez, L., Fabra, P., Castillo, I., Merce, J., & Duda, J. L. (2012). Coaches'
399 interpersonal style, basic psychological needs and the well-and ill-being of young soccer
400 players: A longitudinal analysis. *Journal of Sports Sciences,* 30(15), 1619-1629. DOI:
401 10.1080/02640414.2012.731517
402
403 Cohen, J. (1992). Statistical power analysis. *Current Directions in Psychological Science,* 1(3),
404 98-102.
405
406 Colquhoun, R. J., Gai, C. M., Walters, J., Brannon, A. R., Kilpatrick, M. W., D'agnostino, D. P., &
407 Campbell, W. I. (2017). Comparison of powerlifting performance in trained men using traditional
408 and flexible daily undulating periodization. *Journal of Strength and Conditioning Research,*
409 31(2), 283-291. DOI: 10.1519/JSC.0000000000001500
410
411 Cormack, S.J., Newton, R.U., McGuigan, M.R., & Doyle, T.L.A. (2008). Reliability of measures
412 obtained during single and repeated countermovement jumps. *International Journal of Sports*
413 *Physiology and Performance,* 3(2),131-144. DOI: 10.1123/ijspp.3.2.131 3: 131–144
414
415 Deci, E. L., & Ryan, R. M. (2000). The "what" and "why" of goal pursuits: Human needs and the
416 self-determination of behavior. *Psychological Inquiry,* 11(4), 227-268. DOI:
417 https://doi.org/10.1207/S15327965PLI1104_01
418
419 Dello Iacono, A., Beato, M., & Halperin, I. (2020a). The effects of cluster-set and traditional-set
420 post activation potentiation protocols on vertical jump performance. *International Journal of*
421 *Sports Physiology and Performance,* 15(4), 464-470. DOI: 10.1123/ijspp.2019-0186
422
423 Dello Iacono, A., Beato, M., & Halperin, I. (2020b). Self-selecting the number of repetitions in
424 potentiation protocols enhances jumping performance. *International Journal of Sports*
425 *Physiology and Performance*. In press. DOI: 10.31236/osf.io/dfk9r
426
427 Dragicevic, P. (2016). Fair statistical communication in HCI. In J. Robertson & M. Kaptein
428 (Eds.), *Modern Statistical Methods for HCI* (pp. 291-330). Springer Nature. DOI:
429 https://doi.org/10.1007/978-3-319-26633-6_13
430
431 Emanuel, A., Har-Nir, I., Rozen Smukas, I., & Halperin, I. (2020). The effect of self-selecting the
432 number of repetitions on motor performance and psychological outcomes. Psychological
433 Research (2020). https://doi.org/10.1007/s00426-020-01402-4
434

435 Enoka, R.M., & Duchateau, J. (2008). Muscle fatigue: what, why and how it influences muscle
436 function. Journal of Physiology, 586(1):11-23. DOI:10.1113/jphysiol.2007.139477
437
438 Gonzalez, L., Garcia-Merita, M., Castillo, I., & Balaguer, I. (2016). Youth athletes' perceptions of
439 coach behaviours and their implications on their well- and ill-being over time. *Journal of Strength*
440 *and Conditioning Research,* 30(4), 1147-1154. DOI: 10.1519/JSC.0000000000001170
441
442 Halperin, I., Chapman, D. W., Martin, D. T., Lewthwaite, R., & Wulf, G. (2017). Choices enhance
443 punching performance of competitive kickboxers. *Psychological Research,* 81(5), 1051-1058.
444 DOI: 10.1007/s00426-016-0790-1
445
446 Halperin, I., Pyne, D. B., & Martin, D. T. (2015). Threats to internal validity in exercise science: a
447 review of overlooked confounding variables. *International Journal of Sports Physiology and*
448 *Performance*, 10(7), 823-829.
449
450 Halperin, I., Wulf, G., Vigotsky, A., Schoenfeld, B. J., & Behm, D. G. (2018). Autonomy: A
451 missing ingredient of a successful program? *Strength and Conditioning Journal,* 40(4), 18-25.
452 DOI: 10.1519/SSC.0000000000000383
453
454 Iwatsuki, T., Abdollahipour, R., Psotta, R. Lewthwaite, R., & Wulf, G. (2017). Autonomy
455 facilitates repeated maximum force productions. *Human Movement Science,* 55, 264-268. DOI:
456 10.1016/j.humov.2017.08.016
457
458 Kristiansen, E., & Roberts, G. (2010). Young elite athletes and social support: Coping with
459 competitive and organizational stress in "Olympic" competition. *Scandinavian Journal of*
460 *Medicine & Science in Sports,* 20(4), 686-695. DOI: 10.1111/j.1600-0838.2009.00950.x
461
462 Leech, N. and Onwuegbuzie, A. (2002, November 6-8). *A call for greater statistic*s [Paper
463 presentation]. Annual Meeting of the Mid-South Educational Research Association.
464 Chattanooga, TN, United States of America.
465
466 Lewthwaite, R., Chiviacowsky, S., Drew, R., & Wulf, G. (2015). Choose to move: The
467 motivational impact of autonomy on motor learning. *Psychonomic Bulletin and Review,* 22(5),
468 1383-1388. DOI: https://doi.org/10.3758/s13423-015-0814-7
469
470 Loturco, I., Nakamura, F. Y., Tricoli, V., Kobal, R., Abad, C, Kitamura, K., Ugrinowitsch, C., Gil,
471 S., Pereira, A., & Gonzalez-Badillo, J. (2015). Determining the optimum power load in jump
472 squat using mean propulsive power velocity. *PLOS One,* 10(10), e0140102. DOI:
473 10.1371/journal.pone.0140102
474
475 McNamara, J. M., & Stearne, D. J. (2010). Flexible nonlinear periodization in a beginner weight
476 training class. *Journal of Strength and Conditioning Research,* 24(1), 17-22. DOI: DOI:
477 10.1519/JSC.0b013e3181bc177b
478

479   Micklewright, D., Gibson, A. S., & Salman, A. A. (2017). Development and validity of the rating-
480   of-fatigue scale. *Sports Medicine,* 47(11), 2375-2393. DOI: 10.1007/s40279-017-0711-5
481
482   Nunes, J. P., Grgic, J., Cunha, P. M., Ribeiro, A. S., Schoenfeld, B. J., de Salles, B. F., &
483   Cyrino, E. S. (2020). What influence does resistance exercise order have on muscular strength
484   gains and muscle hypertrophy? A systematic review and meta-analysis. *European Journal of*
485   *Sport Science*, 28 , 1-9. DOI: 10.1080/17461391.2020.1733672
486
487   Othman, A. B., Chaouachi, A., Hammami, R., Chaouachi, M. M., Kasmi, S., & Behm, D. G.
488   (2017). Evidence of nonlocal fatigue in male youth. Applied Physiology, *Nutrition and*
489   *Metabolism,* 42(3), 229-238. DOI: 10.1139/apnm-2016-0400
490
491   Pèrez-Castilla, A., Piepoli, A., Delgado-Garcia, G., Garrido-Blanca, G., & Garcìa-Ramos, A.
492   (2019). Reliability and concurrent validity of seven commercially available devices for the
493   assessment of movement velocity at different intensities during the bench press. Reliability and
494   concurrent validity of seven commercially available devices for the assessment of movement
495   velocity at different intensities during the bench press. *Journal of Strength and Conditioning*
496   *Research,* 33(5):1258-1265. DOI: 10.1519/JSC.0000000000003118
497
498   Ratamess, N. A., Alvar, B. A., Evetoch, T. K., Housh, T. J., Kibler, W. B., Kraemer, W. J., &
499   Triplett, T. N. (2009). American College of Sports Medicine position stand. Progression models
500   in resistance training for healthy adults. *Medicine and Science in Sports and Exercise,* 41(3),
501   687-708. DOI: 10.1249/MSS.0b013e3181915670
502
503   Rauch, J. T., Ugrionowitsch, C., Barakat, C. I., Alvarez, M. R., Brummert, D. L., Aube, D. W.,
504   Barsuhn, A. S., Hayes, D., Tricoli, V., & De Souza, E. O. (2020). Auto-regulated exercise
505   selection training regimen produces small increases in lean mass and maximal strength
506   adaptations in strength-trained individuals. *Journal of Strength and Conditioning Research,*
507   34(4), 1133-1140. DOI: 10.1519/JSC.0000000000002272
508
509   Sands, W. A., Wurth, J. J., & Hewit, J. K. (2012). *The National Strength and Conditioning*
510   *Association' s (NSCA) basics of strength and conditioning manual*. The National Strength and
511   Conditioning Association.
512
513   Silva, M. N., Markland, D. V., Carraca, E. N., Vieira, P. R., Coutinho, S. S., Minderico, C. G.,
514   Matos, M. B., Sardinha, L. J., & Teixeira, P. J. (2011). Exercise autonomous motivation predicts
515   3-yr weight loss in women. *Medicine and Science in Sports and Exercise,* 43(4), 728-737. DOI:
516   10.1249/MSS.0b013e3181f3818f
517
518   Simao, R., de Salles, B. F., Figueiredo, T., Dias, I., & Willardson, J. M. (2012). Exercise order in
519   resistance training. *Sports Medicine,* 42(3), 251-265. DOI: https://doi.org/10.2165/11597240-
520   000000000-00000
521

522   Teques, P., Calmeiro, L., Silva, C., & Borrego, C. (2017). Validation and adaptation of the
523   physical activity enjoyment scale (PACES) in fitness group exercisers. *Journal of Sport and*
524   *Health Science, 9(4), 352-357.DOI: https://doi.org/10.1016/j.jshs.2017.09.010*
525
526   Wulf, G., & Lewthwaite, R. (2016). Optimizing performance through intrinsic motivation and
527   attention for learning: The OPTIMAL theory of motor learning. *Psychonomic Bulletin and*
528   *Review,* 23(5), 1382-1414. DOI: https://doi.org/10.3758/s13423-015-0999-9
529
530
531

Figure 1

Schematic representation of the study design.

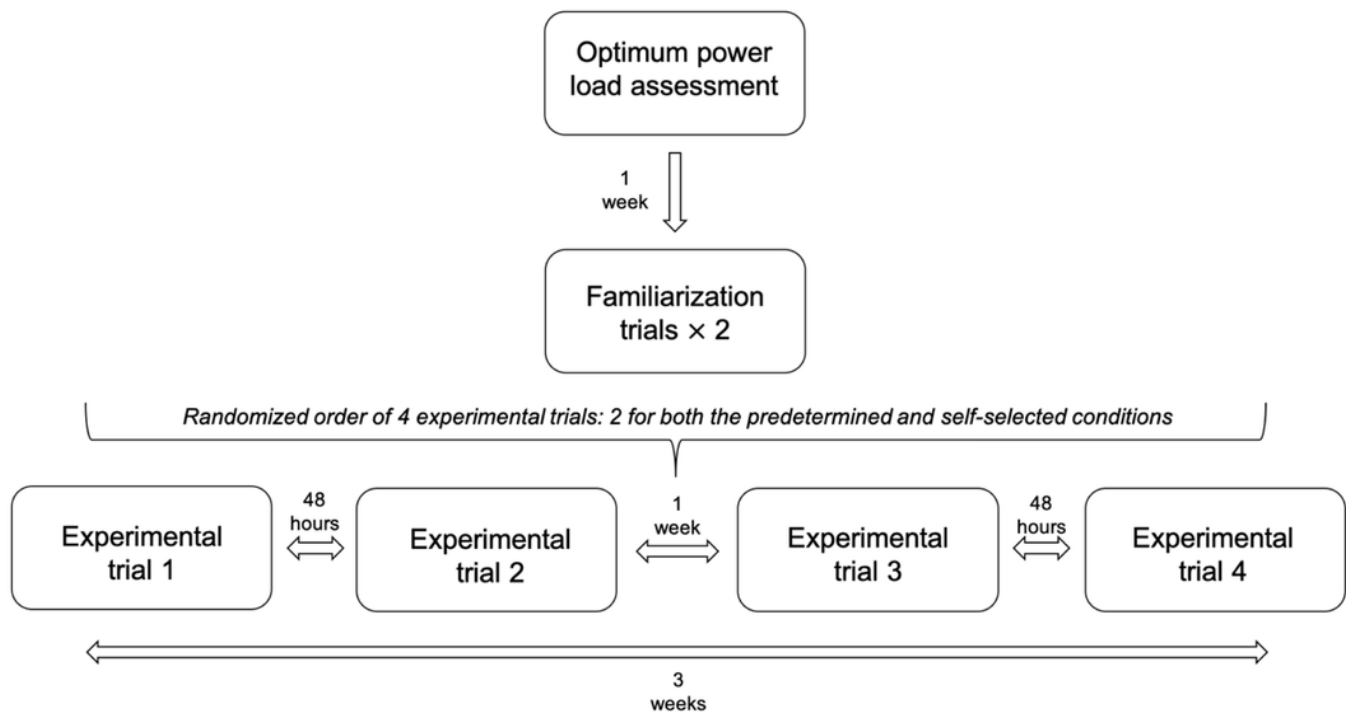



Figure 2

Exercises orders in the self-selected experimental condition

BS: back squat, BP: bench press; BT: bench throw; JS: jump squat

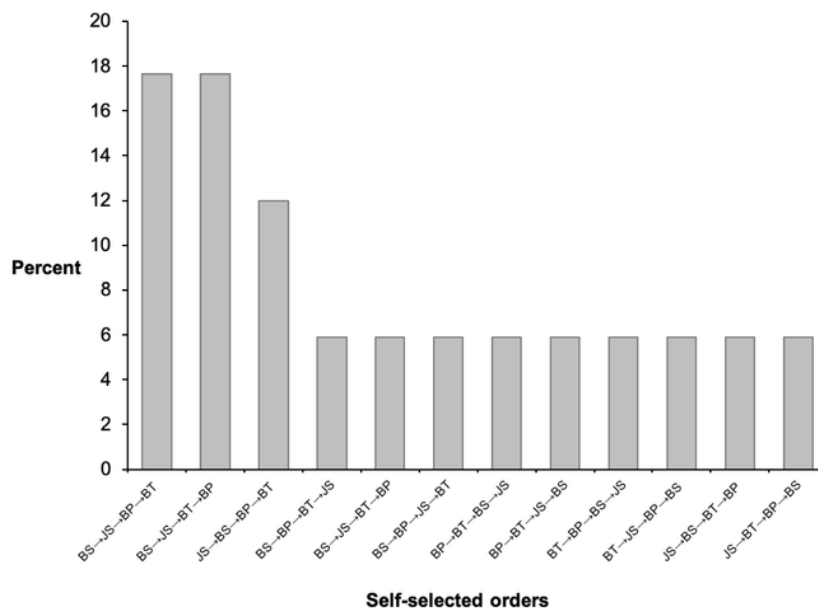



Figure 3

Individual data plots of power outputs for all repetitions performed during each exercise per condition

Each data point indicates the average power output across the same repetition number (1st to 6th) performed in each exercise

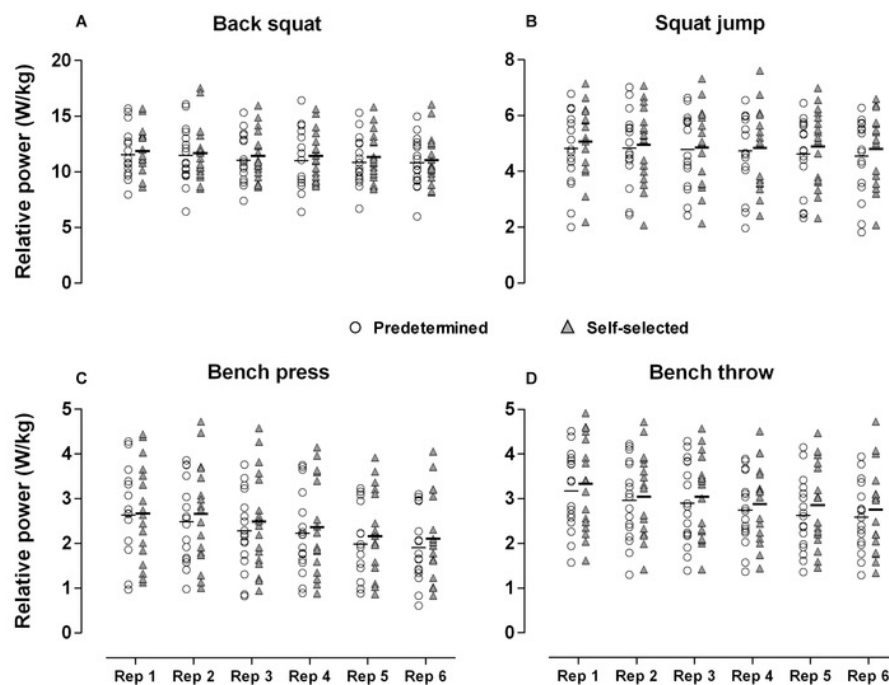



Figure 4

Illustrates the comparative scores between the self-selected and predetermined conditions on power output per exercise

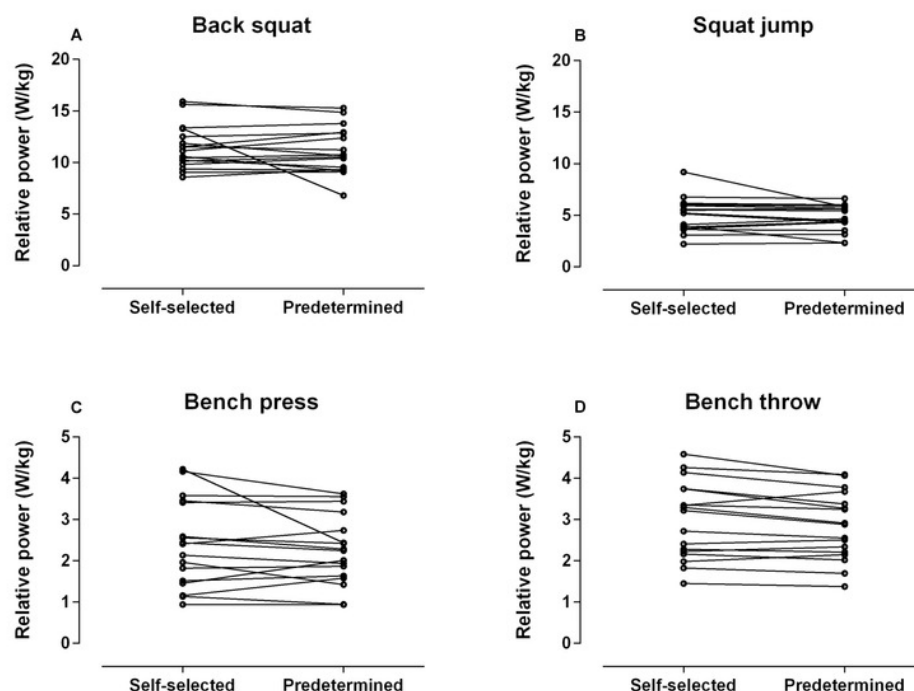
Each data point indicated the average power outputs values (i.e., 36 repetitions) for each participant

Anthropometric characteristics of the participants

Table 1. Anthropometric characteristics of the participants

Skinfolds: triceps, subscapular, biceps, iliac crest, supraspinale, abdominal, thigh, calf.

Skinfolds were collected following the guidelines of International Society for the Advancement of Kinanthropometry

	Male (n = 14)	Female (n = 3)
Age (years)	15.3 ± 1.3	15.0 ± 1.0
Height (cm)	174.2 ± 7.7	166.3 ± 0.2
Body mass (kg)	63.2 ± 10.2	58.0 ± 1.9
Sum of eight skinfolds (mm)	73.1 ± 34.9	107.1 ± 21.3

Descriptive data of OPL and correspondent MPP and reliability (CV% and ICC) scores of MPV across the four sessions for each exercise.

CV: coefficient of variation; 95% CI: 95% confidence interval; ICC: intraclass correlation

coefficient; OPL: optimum power load; MPV: mean propulsive velocity

Table 2. Descriptive data of OPL and correspondent MPP and reliability (CV% and ICC) scores of MPV across the four sessions for each exercise.

CV: coefficient of variation; 95% CI: 95% confidence interval; ICC: intraclass correlation coefficient; OPL: optimum power load; MPV: mean propulsive velocity

Exercise	OPL (kg)		MPV (m/s)		
	Mean ± SD	Range	Mean ± SD	CV (95% CI)	ICC (95% CI)
Back squat	37.0 ± 11.5	21 - 57	0.821 ± 0.082	2.84 (2.39, 3.29)	0.92 (0.84, 0.97)
Jump squat	32.8 ± 13.7	10 - 55	1.024 ± 0.088	2.18 (1.60, 2.76)	0.87 (0.74, 0.95)
Bench press	30.6 ± 7.9	30 - 43	0.827 ± 0.070	1.55 (1.24, 1.86)	0.96 (0.92, 0.98)
Bench throw	21.7 - 6.0	10 - 31	0.858 ± 0.067	1.94 (1.73, 2.16)	0.93 (0.85, 0.97)

Descriptive (mean ± SD), inferential (95% CI) and qualitative statistics (ES) of all variables between self-selected and predetermined conditions

Note: descriptive data are reported as the mean ± SD of the thirty-six repetitions performed during each exercise or subjective questionnaire responses across the two sessions of each experimental condition. Δ: mean difference; CI: confidence interval; ES: effect size; ROF: rate of fatigue; PACES: physical activity enjoyment scale; W: watt; kg: kilogram

Table 3. Descriptive (mean ± SD), inferential (95% CI) and qualitative statistics (ES) of all variables between self-selected and predetermined conditions

Note: descriptive data are reported as the mean **± SD** of the thirty-six repetitions performed during each exercise or subjective questionnaire responses across the two sessions of each experimental condition.

Δ: mean difference; CI: confidence interval; ES: effect size; ROF: rate of fatigue; PACES: physical activity enjoyment scale; W: watt; kg: kilogram

Variable	Self-selected	Predetermined	Δ (95% CI)	ES
Back squat (W/kg)	11.47 ± 2.12	11.11 ± 2.27	0.35 (-0.56, 1.27)	0.16
Jump squat (W/kg)	5.03 ± 1.64	4.72 ± 1.3	0.31 (-0.27, 0.89)	0.21
Bench press (W/kg)	2.41 ± 1.05	2.25 ± 0.84	0.16 (-0.18, 0.50)	0.17
Bench throw (W/kg)	2.98 ± 0.93	2.83 ± 0.83	0.15 (-0.01, 0.32)	0.17
ROF Back squat	5.62 ± 1.59	5.47 ± 1.157	0.15 (-0.74, 1.03)	0.09
ROF Jump squat	6.44 ± 1.37	6.53 ± 1.62	-0.09 (-0.63, 0.46)	-0.06
ROF Bench press	5.88 ± 1.27	6.35 ± 1.59	-0.47 (-1, 0.06)	-0.33
ROF Bench throw	6.12 ± 1.49	6.23 ± 1.68	-0.12 (-0.83, 0.59)	-0.07
PACES	38.3 ± 5.6	38.0 ± 7.2	0.32 (-1.58, 2.23)	0.05