

**The effects of plyometric jump training on jumping and swimming performances in
prepubertal male swimmers**

Running head: Plyometric training and swimming performance

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Key points

- Short-term (i.e., 8 weeks) plyometric jump training conducted during the in-season period is safe and it resulted in substantial improvements in jumping and swimming performances in prepubertal male swimmers.
- Practitioners should consider plyometric jump training when designing their training strategies to improve swimming performance of prepubertal male athletes.

1 **The effects of plyometric jump training on jumping and swimming performances in** 2 **prepubertal male swimmers**

3 **Abstract**

4 Swimming performance can be improved not only by in-water sport-specific training but also
5 by means of dry land-training (e.g., plyometric jump training [PJT]). This study examined the
6 effects of an 8-week PJT on proxies of muscle power and swimming performance in prepubertal
7 male swimmers. Participants were randomly allocated to a PJT group (PJT; n=14; age: $10.3 \pm$
8 0.4 years, maturity-offset = -3 ± 0.3) or a control group (CG; n=12; age: 10.5 ± 0.4 years,
9 maturity-offset = -2.8 ± 0.3). Swimmers in PJT and CG performed 6 training sessions per week.
10 Each training session lasted between 80 and 90 minutes. Over the 8 weeks in-season training
11 period, PJT performed two PJT sessions per week, each lasting between 25 to 30 minutes ($\square 1$
12 hour per week) in replacement of sport-specific swimming drills. During that time, CG followed
13 their regular sport-specific swimming training (e.g., coordination, breathing, improving
14 swimming strokes). Overall training volume was similar between groups. Pre- and post-
15 training, tests were conducted to assess proxies of muscle power (countermovement-jump
16 [CMJ]), standing-long-jump [SLJ]) and sport-specific swimming performances (15-, 25-, and
17 50-m front-crawl, 25-m kick without push [25-m kick WP], and 25-m front-crawl WP). No
18 training or test-related injuries were detected over the course of the study. Between-group
19 analyses derived from magnitude-based inferences showed trivial-to-large effects in favour of
20 PJT for all tests (ES=0.28 to 1.43). Within-group analyses for the PJT showed small
21 performance improvements for CMJ (effect-size [ES] =0.53), 25-m kick WP (ES=0.25), and
22 50-m front crawl (ES=0.56) tests. Moderate performance improvements were observed for the
23 SLJ, 25-m front-crawl WP, 15-m and 25-m front-crawl tests (ES=0.95, 0.60, 0.99, and 0.85,
24 respectively). For CG, the within-group results showed trivial performance declines for the
25 CMJ (ES=-0.13) and the 50-m front-crawl test (ES=-0.04). In addition, trivial-to-small

26 performance improvements were observed for the SLJ (ES=0.09), 25-m kick WP (ES=0.02),
27 25-m front-crawl WP (ES=0.19), 25-m front-crawl (ES=0.2), (SLJ [ES=0.09, and 15-m front
28 crawl (ES=0.36). Short-term in-season PJT, integrated into the regular swimming training, was
29 more effective than regular swimming training alone in improving jump and sport-specific
30 swimming performances in prepubertal male swimmers.

31 **Keywords:** Stretch-shortening cycle, young athletes, rate of force development, sport-specific
32 performance.

33

34 INTRODUCTION

35 From a physical, physiological, and technical-tactical point of view, swimming is a highly
36 demanding Olympic sport and elite performances are achieved at an early age (Nugent et al.,
37 2018). Therefore, commitment to training has to start during the early stages of long-term
38 athlete development (LTAD) to increase the likelihood of sporting success as an elite athlete
39 (Nugent et al., 2018). From a performance and health-related perspective, muscle strength
40 should specifically be promoted during all LTAD stages (Lloyd et al., 2012; Lloyd et al., 2015;
41 Pichardo et al., 2019). In fact, muscle strength should be promoted in young athletes to support
42 motor skill acquisition, to enhance physical fitness and sports performance, to improve markers
43 of health and well-being, and to reduce the risk of sustaining sports-related injuries
44 (Faigenbaum et al., 2013; Faigenbaum et al., 2019; Granacher et al., 2016).

45 More specifically, it has been reported that well-developed levels of muscle strength and power
46 play an important role in achieving high swimming performances (Crowley et al., 2018; Girold
47 et al., 2007; Potdevin et al., 2011). In fact, there is evidence that the ability to exert force in the
48 water is a decisive factor, particularly in sprint swimming (e.g., 50-m, 100-m, and 200-m)
49 (Morouço et al., 2011). Moreover, the swimming start contributes up to 30% of the total race
50 time (Cossor et al., 1999). The shorter the distance the more important becomes an explosive
51 start. West et al. (2011) showed that a successful swimming start depends on a number of factors
52 including reaction time, vertical and horizontal forces generated by lower limb muscles during
53 the push-off phase from the block, and a low resistance during the underwater gliding phase. In
54 addition, during front-crawl swimming, lower limb muscles contribute up to 12% of the
55 propulsion (Ribeiro et al. 2015).

56

57 Swimming performance cannot only be improved through sport-specific in-water training but
58 also by means of dry land-training (i.e., strength and/or power training) (Crowley et al., 2018;

59 Potdevin et al., 2011). Previous studies have shown that particularly plyometric jump training
60 (PJT) is a widely used, safe, and effective training regime to improve muscle strength and power
61 as well as sport-specific performance in prepubertal athletes (Bedoya et al., 2015; Bouguezzi et
62 al., 2018; Chaabene and Negra, 2017; Nugent et al., 2018). In this context, Granacher et al.
63 (2016) introduced a conceptual model for the implementation of resistance training during the
64 different LTAD stages. The same authors suggested a variety of resistance training approaches
65 that can be used across the different maturation stages, among them PJT (Granacher et al. 2016).
66 However, it is noteworthy that PJT should not be used as a stand-alone component of an
67 exercise program and the advisable approach is to incorporate supervised and progressive
68 power training into a well-rounded program that also involves other types of strength and
69 conditioning (Behm et al., 2008; Behm et al., 2017).

70 Only a few studies examined the effects of PJT executed outside the pool on swimming
71 performance (Bishop et al., 2009; Potdevin et al., 2011; Rejman et al., 2017). For instance,
72 Bishop et al. (2009) studied the effects of an 8-week combined PJT and swimming training on
73 swim start performance in adolescent swimmers and observed significant improvements in
74 velocity from take-off to water contact ($\Delta 15.6\%$) and 5.5-m performance time (15.4%).
75 Rebutini et al. (2016) conducted a 9-week PJT program with adolescent male and female
76 swimmers and showed improvements in peak torque and rate of torque development of the hip
77 ($\Delta 47\%$ and 108% , respectively) and knee joints ($\Delta 24\%$ and 41% , respectively) during swim
78 start performance.

79

80 Most of the available studies focused on the effects of PJT on swim start performance and the
81 underpinning kinetic and kinematic parameters (Bishop et al., 2008; Rebutini et al., 2016).
82 Notably, Potdevin et al. (2011) examined the effects of a 6-week PJT on particularly sport-
83 specific swim performances in adolescent male swimmers (age= 14.3 ± 0.2 years). These authors

84 revealed significant increases in 50-m (ES=0.1, Δ 3.1%) and 400-m (ES=0.15, Δ 4.2%) average
85 swimming speed as well as in countermovement jump and squat jump performances (ES=1.66
86 and 2.37, respectively). To the authors' knowledge, there is no study available that investigated
87 the effects of PJT on proxies of muscle power and sport-specific swimming performance in
88 prepubertal male swimmers. Therefore, it is timely and imperative to elucidate whether the
89 findings of Potdevin et al. (2011) in adolescent swimmers can be translated to prepubertal
90 swimmers as well. Accordingly, this study sought to examine the effects of an 8-week PJT
91 program in combination with swimming compared with swimming only on proxies of muscle
92 power (i.e., countermovement jump [CMJ], standing long jump [SLJ]) and sport-specific
93 swimming performances in prepubertal male swimmers. With reference to the relevant
94 literature (Potdevin et al., 2011; Rebutini et al., 2016), we hypothesized that the combination
95 of PJT and swimming results in larger jump and sport-specific performance improvements than
96 regular swimming training alone in prepubertal male swimmers.

97

98 **METHODS**

99 *Experimental approach to the problem*

100 A randomized controlled trial was conducted to examine the effects of an 8-week PJT program
101 on proxies of muscle power and sport-specific swimming performances in prepubertal male
102 swimmers. One week before baseline testing, two familiarization sessions were performed to
103 get participants accustomed to the physical fitness tests and the plyometric drills. The respective
104 test sessions were 5 days apart. Before and after the intervention, tests were conducted to assess
105 jump (i.e., CMJ, SLJ) and swimming performances. Sport-specific testing included a timed 15,
106 25, and 50-m front crawl tests with a diving start, a timed 25-m front crawl test without push-
107 off from the wall (25-m WP), and a 25-m kick timed test without push-off from the wall (25-m
108 KWP). All tests were conducted in an indoor swimming pool with a water temperature of 26°C

109 which is in agreement with recommendations from the Federation Internationale de Natation
110 (2014). Testing was conducted 48 hours after the last training session and at the same time of
111 the test day (7:30-9:30 p.m.).

112

113 *Participants*

114 A total of twenty-six prepubertal male swimmers participated in this study. They were randomly
115 allocated to a PJT group (PJT; n=14; age= 10.3±0.4 years; maturity offset=-3.1±0.3) or an
116 active control group CG (n=12; age= 10.5±0.4 years; maturity offset=-2.8±0.3). The PJT
117 performed six training sessions per week, including two PJT sessions which were integrated
118 into the regular sport-specific training schedule in replacement of some swimming specific
119 drills. The remaining training time comprised technical drills. CG followed their regular sport-
120 specific swimming training (i.e., six sessions per week) throughout the intervention period.
121 Training volume was similar between groups. Prior to the start of the study, all young athletes
122 performed twice per week strength endurance exercises for muscles of the upper and lower
123 limbs and the trunk using the own body-mass. The strength training program included push-
124 ups, abdominal curls, back extensions, and squats. Participating athletes completed up to 5 sets
125 of 15 repetitions each with a 30 seconds rest in-between sets. Training was conducted over 3
126 weeks to get the participants prepared for the subsequent plyometric training program.

127 All participants were competing on a national level within their respective age category. They
128 had a background of 2.0 ± 1.6 years of systematic swimming training involving five to six
129 training sessions per week throughout the season. Further, all participants were healthy and free
130 of musculotendinous injuries over the last 6 months prior to the start of the study. Participants
131 who missed more than 20% of the total PJT sessions and/or more than two consecutive PJT
132 sessions were excluded from the study. The maturation status was determined at the beginning
133 and after 8 weeks of training according to the maturity offset method (Malina et al., 2014).

134 Maturity offset (expressed in years) was defined as the time before or after peak-height-
135 velocity. All participants and their legal representatives were properly informed about all testing
136 and training procedures, as well as potential benefits and harms related to the study. Verbal and
137 written informed consent (legal representatives) and assent (children) were obtained before the
138 start of the experiment. All procedures were approved by the local Institutional Review
139 Committee of the Higher Institute of Sport and Physical Education, Ksar Said, Tunisia. All
140 procedures were in accordance with the latest version of the Declaration of Helsinki.

141

142 **Anthropometric measures**

143 Anthropometrical measurements (i.e., body-mass, height) were taken by a trained
144 anthropometrist assisted by a recorder. Standardized procedures were applied in accordance
145 with the International Society for the Advancement of Kinanthropometry (ISAK) (Stewart et
146 al., 2011) (Table 1).

147

148 ***Proxies of muscle power***

149 *Countermovement jump*

150 For CMJ testing, participants started from an upright erect standing position, performed a fast
151 downward movement by flexing the knees and hips immediately followed by a rapid leg
152 extension resulting in a maximal vertical jump. Throughout the execution of the test,
153 participants maintained their hands on the hips and elbows turned outward. CMJ techniques
154 were visually controlled by the first author of this study. Jump height was recorded using an
155 Optojump photoelectric system (Microgate, SRL, Bolzano, Italy). The intraclass correlation
156 coefficient (ICC) for test-retest reliability was 0.98 and the typical error of measurement (TEM)
157 was 2.9%.

158

159 *Standing long jump*

160 The starting position of the SLJ required subjects to stand with their feet shoulder-width apart
161 behind a starting line and their arms loosely hanging down at the sides of their body. On the
162 command ready, set, go, participants executed a countermovement with their legs and arms and
163 jumped at maximal effort in horizontal direction. Participants had to land with both feet
164 simultaneously and could not fall forward or backward. The horizontal distance between the
165 starting line and the heel of the rear foot was recorded via tape measure to the nearest 1-cm.
166 The ICC for test-retest reliability was 0.96 and the TEM was 0.5%.

167

168 *Sport-specific swimming tests*

169 Swimming time trials expressed in seconds were adopted as our measures of sport-specific
170 performance. All tests were conducted in a 50-m indoor-swimming pool. Swimmers performed
171 two front crawl swimming trials with a diving start (15, 25, and 50-m) and two trials with a
172 water start without a push-off from the wall (25-m WP and 25-m KWP). All starts were
173 voluntarily initiated by the swimmers. Two independent observers recorded performance times
174 using stop-watches. The average of the two recorded values was used for further statistical
175 analyses. The start signal for the observer was the moment as the swimmers' feet left the block.
176 For the water start without push-off, swimmers' first lower limb movement was used as an
177 indicator to start timing. The distance was standardized using markers at the bottom of the pool.
178 The final signal for the observer was the moment when the swimmers' hand touched the wall.
179 The ICC for test-retest reliability ranged between 0.89 and 0.91 and the TEM ranged between
180 1.2 and 2.5% for all swimming tests.

181 *Plyometric jump training*

182 The PJT intervention was conducted during the competitive period of the year (March-April
183 2018). The program lasted 8 weeks with two sessions per week. Plyometric jump training
184 sessions were integrated into the regular training routine of the swimmers in replacement of
185 some swimming specific drills. The remaining training time comprised technical drills
186 (coordination, breathing, improving swimming strokes). The second PJT session was
187 completed 72 hours after the first one to provide a sufficiently long enough recovery period
188 between sessions. Each swimming training session lasted between 80 and 90 minutes. PJT drills
189 lasted between 25 and 30 minutes. During that time, CG conducted their regular sport-specific
190 training. Thus, both experimental groups experienced similar training volumes. Overall, 6
191 training sessions were conducted per week, each lasting between 80 to 90 minutes. No
192 competitions were scheduled over the entire study period. Our PJT protocol was in accordance
193 with previously published PJT recommendations for young athletes (Bedoya et al., 2015). At
194 the beginning of the intervention, a focus was placed on proper exercise technique (e.g.,
195 landing). All jump exercises were performed on a stable surface (i.e., grass) and at maximal
196 effort (CMJs) with minimal ground contact time. Both PJT sessions comprised 8-12 sets with
197 6–10 repetitions each. The total ground contacts per week gradually increased from 50 during
198 the first week to 120 during the last week of training (Bouguezzi et al., 2011; Negra et al.,
199 2017). A 90-second rest was provided between each set of exercise to allow sufficient recovery
200 time.

201

202 **STATISTICAL ANALYSES**

203

204 Between-group baseline differences in anthropometric characteristics, maturity-offset, and
205 physical fitness were verified using t-tests for independent samples. Magnitude-based
206 inferences were applied to calculate and interpret effect sizes. In this regards, effect sizes <0.2

207 were considered trivial, between 0.2–0.6 small, between 0.6–1.2 moderate, between 1.2–2.0
208 large, between 2.0–4.0 = very large and finally >4.0 = extremely large (Hopkins et al., 2009).
209 The estimates were considered unclear when the chance of a beneficial effect was high enough
210 to justify the use of the intervention, yet the risk of being harmful was unacceptable. An odds
211 ratio of benefit to harmful of <66 indicated such unclear effects (Hopkins, 2017). This odds
212 ratio corresponds to an effect that is borderline possibly beneficial (25% chance of benefit) and
213 borderline most unlikely detrimental (0.5% risk of harm). This was calculated using a publicly
214 available spreadsheet (Hopkins, 2017). Otherwise, the effect was clear and was interpreted as
215 the magnitude of the observed value, with the qualitative probability that the true value was at
216 least of this magnitude. The scale used to interpret the probabilities was as follows: possible =
217 25–75%; likely = 75–95%; very likely = 95–99.5%; most likely >99.5% (Hopkins et al., 2009).
218 Uncertainty in effect sizes was represented by 90% confidence limits. Effects were considered
219 unclear if the confidence interval crossed thresholds for substantial positive and negative
220 values. Otherwise, the effect was clear and reported as the magnitude of the observed value
221 with a qualitative probability (Hopkins et al., 2009). Before the start of the training intervention,
222 relative and absolute test-retest reliability was assessed for all tests prior to the start of the study
223 using ICC, and TEM.

224

225 **RESULTS**

226 Adherence rates to swimming training were 96% for both groups. Of note, no training- or test-
227 related injuries occurred during the study. All participants in the PJT and the CG received
228 treatments as allocated. Two participants from CG were excluded because of their high absence
229 rate. The computed ICC values indicated excellent reliability with ICCs ranging from 0.89 to
230 0.96. Table 3 displays data of pre-post tests for proxies of muscle power and sport-specific
231 swimming performances. There were no statistically significant between-group baseline

232 differences for chronological age, body height, body-mass, maturity-offset or swimming
233 expertise (Table 1). Additionally, no between-group differences were recorded at baseline
234 regarding proxies of muscle power and sport-specific swimming performances (Table 3).

235 The between-group analyses revealed trivial to large effect sizes in favour of PJT_G for all
236 physical fitness tests (Table 4). Within-group analyses for the PJT_G group showed small effect
237 sizes for the CMJ, 25-m KWP, and 50-m front crawl test (Table 3). In addition, moderate
238 performance improvements were observed for the SLJ, 25-m WP, 15-m and 25-m front crawl
239 tests. Regarding the CG group, trivial effect sizes were observed for the CMJ, SLJ, 25-m KWP,
240 and 25-m WP test. In the 50-m front crawl test, a small performance decline was noted. For the
241 15-m front crawl, small improvements were recorded.

242

243 **DISCUSSION**

244

245 This study is the first to examine the effects of an 8-week PJT in combination with swimming
246 training compared with swimming training only on proxies of muscle power and swimming
247 performances in prepubertal male swimmers. The main findings showed that equal volume PJT
248 combined with regular swimming training is more effective than regular swimming training
249 alone in improving jump and swim performances.

250

251 *Muscle power*

252 Findings of this study showed that PJT combined with swimming training induced small
253 (ES=0.53) and moderate (ES=0.95) improvements for CMJ height and SLJ while regular
254 swimming training alone produced trivial changes in CMJ height and SLJ (ES=-0.13, and 0.09,
255 respectively) only. Improvements in vertical and horizontal jump performances were expected

256 considering the large number of studies that reported performance enhancements in prepubertal
257 children following this type of intervention (Bedoya et al., 2015; de Villarreal et al., 2009;
258 Negra et al., 2018). For instance, Potdevin et al. (2011) studied the effects of PJT on proxies of
259 muscle power (i.e., CMJ, SJ) in adolescent male and female swimmers aged 13 to 15 years.
260 These authors revealed significant improvements in CMJ and squat jump height (ES=1.73, and
261 0.73, respectively) after 6 weeks of training. In agreement with the findings of Potdevin et al.
262 (2011), de Villarreal et al. (2015) showed a significant improvement in CMJ height (ES=0.66)
263 after 6 weeks of PJT in professional male water-polo players aged 23 years. The marked jump
264 height improvements could mainly be caused by neural adaptations (Hakkinen and Komi, 1985;
265 Markovic and Mikulic, 2010) in the form of enhanced motor unit activation of lower extremity
266 muscles (i.e., intramuscular coordination) (Taube et al., 2007) and improved intermuscular
267 coordination in conjunction with decreased co-activation of antagonistic muscles (Taube et al.,
268 2007). However, further studies are needed that examine the underlying neuromuscular
269 mechanisms responsible for training-induced performance improvements.

270

271

272 *Sport-specific swimming performances*

273

274 Results of the present study showed that PJT combined with regular swimming training induced
275 small-to-moderate improvements in the 50-m front crawl test (ES=0.56), and the 15-m
276 (ES=0.99) as well as 25-m front crawl tests (ES=0.85). The regular swimming training
277 generated trivial-to-small benefits in the 25-m (ES=0.20) and 15-m front crawl (ES=0.36) only.
278 Of note, trivial performance declines were found for the 50-m front crawl test (ES=0.04). There
279 is controversy in the literature as to the potential contribution of PJT on swimming performance
280 enhancements. For instance, Cossor et al. (1999) showed non-significant improvements in the

281 50-m front crawl test after a 20-week PJT program in young swimmers aged 12 years. Unlike
282 the previous study, Potdevin et al. (2011) revealed significant increases in 50-m, and 400-m
283 average swimming speed after a 6-week PJT program in adolescent male and female swimmers
284 (ES=0.1, and 0.15 for 50-m, and 400-m, respectively). Similarly, in elite female water-polo
285 players, Veliz et al. (2015) observed increases in 20-m sprint swim time (ES=0.56) after 16
286 weeks of combined lower-body resistance and PJT training. These contradictory findings are
287 most likely due to differences in the applied methods and study cohorts (prepubertal vs.
288 adolescent, male swimmers vs. male and females, type of plyometric exercises, frequency,
289 duration, and progression of training). According to the aforementioned studies (Potdevin et
290 al., 2011; Veliz et al., 2015), improvements in swimming performances have been associated
291 with increases in lower limbs power output, which may translate to a higher force application
292 in the water. In addition, improvements observed after the PJT program may have been induced
293 by an increased neural drive to the agonist muscles, improved intermuscular coordination,
294 changes in musculotendinous stiffness, and changes in single-fiber mechanics (Markovic and
295 Mikulic, 2010).

296 This study has some limitations that warrant discussion. First, we were only able to assess
297 performance but not physiological data which is why we cannot provide evidence on the
298 underlying neuromuscular mechanisms responsible for the observed findings. Future studies
299 are advised to include electrophysiological testing apparatus. Second, the training load was not
300 directly monitored in both groups. Nevertheless, all participating athletes performed on the
301 same competition level and followed the same swimming training program which consisted of
302 five to six training sessions per week. As such, we are confident that both groups experienced
303 comparable overall training loads. In addition, while waiting in-water for the tests to be started,
304 a slight drift forward and / or backward while floating on the water may have occurred.
305 Furthermore, the rather small sample size may constitute another limitation. However, having

306 access to a larger sample of young swimmers is challenging due to the reduced number of young
307 subjects competing on the national level. Finally, given that the currently applied PJT program
308 induced small-to-moderate improvements in the experimental group, it is possible that a longer
309 training intervention (i.e., >8 weeks) may induce even larger performance enhancements.
310 However, this needs to be examined in future studies given that dose-response relations for PJT
311 are not yet established in prepubertal athletes.

312

313 **Conclusions**

314 In conclusion, results from this study showed that the combination of a short-term in-season
315 PJT program with regular swimming training is more effective than regular swimming training
316 alone in improving jump and swimming performances in prepubertal male swimmers.
317 Accordingly, practitioners should consider PJT during the competitive period of the season to
318 improve swimming performance in prepubertal male swimmers. Of note, a special emphasis
319 should be placed on landing biomechanics and technical execution during training to avoid
320 acute and/or overload injuries. This is, particularly, needed with young athletes who are
321 unfamiliar with PJT. To further improve the effectiveness and safety of PJT in young athletes,
322 coaches are advised to incorporate strength training prior to PJT. This can be realized during
323 the pre-season to lay an adequate foundation for more power-based training (Behm et al. 2017).

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Table 1: Anthropometric characteristics of the included subjects

	PJT (n=14)		CG (n=12)	
	Pre-test	Post-test	Pre-test	Post-test
Age (years)	10.3±0.4	10.5±0.4	10.5±0.4	10.7±0.4
Body height (cm)	142.5±7.9	143.2±8.1	145.71±6.7	146.2±7.2
Body mass (kg)	36.2±8.4	36.66±8.2	38.2±5.9	38.7±5.9
Maturity offset	-3.1±0.4	-3.09±0.4	-2.88±0.4	-2.8±0.4
Predicted APHV	13.4±0.5	13.61±0.5	13.40±0.3	13.5±0.4

Notes: Data are presented as means and standard deviations (SD); PJT: Plyometric jump training; CG: Control group; APHV: Age at peak-height-velocity.

Table 2: Characteristics of the plyometric jump training programs

Week	Plyometric exercises	Volume (sets×reps)	Ground contacts
1	Bilateral ankle hops (hurdle height: 20 cm),	4 × 6-7	50
	CMJs	4 × 6-7	
2	Bilateral ankle hops (hurdle height: 20 cm),	4 × 7-8	60
	CMJs	4 × 7-8	
3	Bilateral ankle hops (hurdle height: 20 cm),	4 × 8-9	70
	CMJs	4 × 9	
4	Bilateral ankle hops (hurdle height: 20 cm),	4 × 10	80
	CMJs	4 × 10	
5	Bilateral ankle hops (hurdle height: 20 cm),	4 × 10	90
	CMJs	6 × 8-9	
6	Bilateral ankle hops (hurdle height: 20 cm),	6 × 8-9	100
	CMJs	6 × 8-9	
7	Bilateral ankle hops (hurdle height: 20 cm),	6 × 8	110

	CMJs	6 × 10	
8	Bilateral ankle hops (hurdle height: 20 cm),	6 × 10	120
	CMJs	6 × 10	

Reps: repetitions; Notes: CMJ: countermovement jump

Table 3: Within-group effect sizes, confidence limits, likelihood effects and odds ratio for performance data

Variable	Baseline	Post-test	Effect size	Confidence limits	Likelihood effect is beneficial (%)	Likelihood effect is trivial (%)	Likelihood effect is harmful (%)	Effect description	Odds ratio of benefits to harm
plyometric jump training group (n= 14)									
CMJ (cm)	19.7±3.8	21.7±3.7	0.53	-0.1 to 1.2	85.5%	13.0%	1.5%	Likely beneficial	389
SLJ (cm)	134.3±15.7	148.4±13.9	0.95	0.3 to 1.6	90.7%	6.7%	2.6%	Likely beneficial	380
25-m KWP (s)	29.0±2.7	28.4±2.5	0.25	-0.9 to 0.4	63.6%	36.1%	0.4%	Possibly beneficial	487
25-m WP (s)	20.3±1.0	19.7±1.0	0.60	-1.2 to 0.0	87.1%	11.2%	1.7%	Likely beneficial	383
15-m front crawl (s)	10.1±0.5	9.6±0.4	0.99	-1.6 to -0.3	90.9%	6.4%	2.6%	Likely beneficial	369
25-m front crawl (s)	18.2±0.9	17.52±0.7	0.85	-1.5 to -0.2	90.1%	7.6%	2.4%	Likely beneficial	372
50-m front crawl (s)	40.0±1.7	39.1±1.5	0.56	-1.2 to 0.1	86.2%	12.2%	1.6%	Likely beneficial	386
Control group (n=12)									
CMJ (cm)	19.9±3.7	19.4±3.0	0.13	-0.8 to 0.5	17.7%	82.2%	0.0%	Likely trivial	526

SLJ (cm)	140.2±27.3	142.7±25.5	0.09	-0.6 to 0.8	2.5%	97.5%	0.0%	Very likely trivial	426
25-m KWP (s)	25.3±2.3	25.2±1.8	0.02	-0.7 to 0.7	0.0%	100.0%	0.0%	Most unlikely trivial	8
25-m front crawl WP (s)	18.6±1.9	18.9±1.7	0.19	-0.5 to 0.9	46.3%	53.5%	0.2%	Possibly trivial	480
15-m front crawl (s)	9.53±0.8	9.3±0.8	-0.36	-1.0 to 0.3	77.9%	21.2%	0.9%	Likely beneficial	400
25-m front crawl (s)	17.17±1.2	16.9±1.4	0.20	-0.9 to 0.5	50.0%	49.8%	0.2%	Possibly beneficial	472
50-m front crawl (s)	37.5±2.8	37.6±4.0	0.04	-0.6 to 0.7	0.0%	100%	0.0%	Most likely trivial	51

CMJ: countermovement jump; SLJ: standing long jump; 25-m KWP: 25-m kick without push; 25-m WP: 25-m front crawl without push.

Table 4: Between-group effect sizes, confidence limits, likelihood effects and odds ratios for performance data

Variable	Mean difference	Effect size	Confidence limits	Control is beneficial (%)	Similar (%)	Plyometric is beneficial (%)	Effect description	Odd ratio of benefits to harm
CMJ (cm)	-2.2	-0.66	-1.32 to 0.00	1.8%	10.5%	87.7%	Likely beneficial	399
SLJ (cm)	-5.7	-0.28	-0.93 to 0.37	0.4%	31.1%	68.5%	Possibly beneficial	605
25-m KWP (s)	-3.1	-1.43	-2.15 to -0.71	3.1%	4.6%	92.3%	Likely beneficial	369
25-m WP (s)	-0.8	-0.62	-1.28 to 0.04	1.6%	11.3%	87.1%	Likely beneficial	404
15-m front crawl (s)	-0.4	-0.60	-1.26 to 0.06	1.6%	11.7%	86.7%	Likely beneficial	407
25-m front crawl (s)	-0.6	-0.58	-1.24 to 0.08	1.5%	12.2%	86.3%	Likely beneficial	411
50-m front crawl (s)	-1.5	-0.50	-1.16 to 0.15	3.2%	4.4%	92.4%	Likely beneficial	368

CMJ: countermovement jump; SLJ: standing long jump; 25-m KWP: 25-m kick without push; 25-m WP: 25-m front crawl without push.