

1 *Original Article*

2 **The Effectiveness of Progressive and Traditional** 3 **Coaching Strategies to Improve Sprint and Jump** 4 **Performance across Varying Levels of Maturation** 5 **within a General Youth Population**

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10 **Abstract:** Literature pertaining to youth development has identified the importance of
11 understanding the physical, intellectual and emotional needs of adolescent youth. The purpose of
12 this study was to compare the use of a ‘traditional’ and ‘progressive’ coaching style to train a general
13 male youth population to improve sprint and jump performances, whilst assessing enjoyment to
14 comment on long term application. Maximal sprint times, sprint kinematics, unilateral jump
15 distances and repetitive tuck jump scores were measured alongside anthropometric variables to
16 characterise performance. Results revealed significant ($p>0.05$) pre/post differences in
17 anthropometric variables across all maturation groups, and each of the maturational levels
18 displayed a tendency to favour a particular coaching or control condition. Pre-PHV groups
19 responded most effectively to the progressive style of coaching, displaying improvements in
20 horizontal jump performances, and -0.7 to -2.7% improvements in all sprint times, despite also
21 showing the largest increase in tuck jump scores (25.8%). The circa-PHV group produced their
22 greatest improvements in the traditional intervention, as displayed through significant
23 improvements ($p<0.05$) in 20m sprint times and dominant-leg horizontal jump performance, whilst
24 also revealing the greatest deterioration in tuck jump scores (14.2%). Post-PHV displayed the
25 greatest improvements in the control setting, suggesting the natural benefits gained through
26 adolescent development were greater than the influence of the training interventions. In conclusion,
27 it is suggested that matching coaching strategies and delivery techniques to the period of biological
28 maturation may have implications for both performance and athlete safety.

29 **Keywords:** PHV; sprint; jump; coaching; adolescent

30

31 **1. Introduction**

32 The use of long-term athlete development (LTAD) models have become widely discussed and
33 implemented by coaches within sporting programmes working within the youth setting [1–3].
34 These models aim to cater to the highly variable and non-linear nature of adolescent development
35 by targeting age appropriate activity in an athlete-centred manner [4]. Youth coaches invested in
36 these models promote discrete alterations in training focus throughout their sporting journey to
37 allow individual growth and help create a positive relationship with exercise, ultimately aiming to
38 preserve long-term participation [4]. The need for variety and individualisation within training
39 regimes is critical due to the variable onset of peak height velocity (PHV) during the adolescent
40 growth spurt. This gene-based, hormone-driven biological process dictates the rate and timing of
41 physical and neurological maturation [5,6]. Due to the unpredictability in the length and intensity
42 of this growth phase, it is common to see a large range in physical, psychological and emotional
43 aptitudes within individuals of a similar chronological age [7]. Accompanying these changes are a

44 rise in the risk of both structural and soft tissue injuries due to the increased rate of growth in bones
45 and muscles [8,9]. Neurologically, this process includes the progressive myelination of axons,
46 accompanied by synaptic and axonal pruning [10]. This development may be expressed through
47 alterations in regular behaviour, risk-taking, emotional responsiveness, as well as the individuals
48 need for cognitive stimulation and sensation [11], and also through a phenomenon identified as
49 'adolescent awkwardness' which is used to describe the process of long bone growth prior to
50 muscular growth, which can lead to a period of disruption in motor coordination [3]. The
51 corresponding effects of these neurological and behavioural adaptations may have implications for
52 learning needs, learning effectiveness and learning styles [12].

53 Past research has investigated strategies such as Athlete-centred learning [13], Game sense [14],
54 Teaching games for understanding (TgfU) [15], and numerous types of coach-feedback strategies
55 [16,17], aimed at optimising learning within a range of populations. Experimental studies
56 investigating these topics have highlighted improvements in recognition performance, motor skills,
57 emotional aptitude and decision making [18–20], which prompt further examination into their
58 application in various contexts. Despite these investigations, there is limited research into the
59 success of these strategies during arguably one of the most important developmental ages for
60 youth; PHV. These pre-mentioned coaching strategies share key overlapping themes with slight
61 variations in application, delivery and/or targeted outcomes. Key similarities between these
62 strategies include the importance placed on the athletes need to interact, apply and discover
63 learning for themselves, have fun, group interaction, problem solving, decision making and finally,
64 learning through numerous interactions with technical, tactical or physical material in a range of
65 contexts; which will collectively be referred to as 'progressive' coaching from here-on and so-forth.
66 These methods are in contrast to a more traditional approach to coaching which typically
67 encompass technical drill-based methods, providing repetition and technical awareness for the
68 individual prior to competing in the sport [21]. One particular study utilised a traditional style of
69 coaching alongside a 'strategy-orientated' approach and identified that badminton serving skills
70 improved most when taught utilising the traditional methods [22]. This approach provides an
71 intimate context to teach, refine, and modify sport specific movements through repetition and
72 exposure to the required technical skills [21,23,24], and may provide a more effective coaching style
73 in some environments.

74 Based on current literature surrounding the individual variation in physical, cognitive and
75 emotional aptitudes within the adolescent population, a coaches' role is to ensure learning is
76 maximised through purposeful pursuits to stimulate the minds of youth via planned and strategic
77 coaching methods. Previous successful application of TGfU, Game sense, Athlete-centred coaching
78 and also a traditional approach to coaching, suggest their use throughout a range of movement
79 contexts is warranted; however, they may be difficult to implement within some individual sports,
80 or training groups, due to the lack of team and group interactions available, and the level of buy-in
81 from coaches [21]. If learning and retention can be maximised within these cohorts of varying levels
82 of biological maturation, then athlete independence, enjoyment, knowledge and physical longevity
83 within sport can be improved; ultimately keeping them interested in the sport for longer.

84 The aim of this study is to build on the findings of previous literature [25] and further inform
85 literature pertaining to within-PHV characteristics. This study will utilise two different coaching
86 approaches (traditional and progressive) to identify the most effective strategy to improve sprint
87 and jump performance within pre, circa and post-PHV maturation groups. Injury markers,
88 movement kinematics and performance measures will provide insight into alterations in movement
89 that occur during the intervention, whilst enjoyment will be measured to provide insight into
90 athlete engagement. Due to the success of the TGfU and Game sense approaches in different
91 cohorts, it is hypothesised that a progressive coaching style will produce the greatest improvements
92 in sprint and jump performance within the pre and post maturation groups when compared to the
93 traditional coaching group, as well as display a decrease in injury markers. It is hypothesised that

94 the circa maturation group will respond best to the traditional coaching methods, as the individual
 95 focus and direct feedback may limit the detrimental influence of adolescent awkwardness. Finally,
 96 it is hypothesised that enjoyment will remain consistent throughout both coaching strategies
 97 because of the short-term application of the intervention.

98 2. Materials and Methods

99 Study design

100 This study utilised a semi-randomized test - retest design, which compared descriptive data from
 101 three distinct maturation groups (pre, circa, and post-PHV), under three separate conditions
 102 (traditional coaching, progressive coaching, and control), within the targeted male youth
 103 population of a single high school. Those individuals within the control and training groups were
 104 pre-determined due to schooling physical education class allocation, however the traditional and
 105 progressive groups were randomised based on individual maturation representation.
 106 Representative groups were allocated post pre-testing with the use of a sex-specific PHV calculation
 107 [7] which utilises height, seated height and limb length, to measure maturation offset (pre < -0.50,
 108 circa -0.49 to +0.49, post > +0.5) [26]. Despite this equation having a reported variance of ± 0.592 yrs
 109 [27], the allocations were made in accordance with similar studies [27,28], and to allow better
 110 distribution across maturation groups within this population.

111 Participants

112 A total of 111 youth males (age 13.2 - 15.7 yrs; maturity offset -1.0 to 2.6 yrs) from a single high
 113 school volunteered for this project. A completed health questionnaire with no contraindications,
 114 and guardian consent were required to partake in this study. There were no fitness, or sporting
 115 requirements of the participants as a representation of general youth ability was sought. Due to the
 116 use of a single high school there was a mix of athletic and non-athletic individuals within the tested
 117 population. Inclusion criteria for data analysis required pre and post testing completion, in addition
 118 to an 80% completion of training sessions for the training groups. These criteria led to a 25.2%
 119 dropout from the initial 111 volunteers (traditional = 9.9%, progressive = 7.2%, control 8.1%). Full
 120 data sets were recorded for a total of 83 participants (traditional n = 28, progressive n = 30, control n
 121 = 25), with Table 1 displaying these group characteristics per training and maturation group. Ethical
 122 approval was granted for all procedures from the institutes' ethics committee.

Table 1: Descriptive anthropometric statistics for training and maturation groups (Mean \pm SD)

Maturation group	Training Group	N	Age (y)	Height (cm)	Weight (kg)	Maturity offset (y)
Pre-PHV	CT	3	13.5 \pm 0.2	155.7 \pm 1.5	43.1 \pm 2.1	-0.8 \pm 0.2
	Trad	4	13.9 \pm 0.7	154.7 \pm 2.9	45.4 \pm 3.1	-0.7 \pm 0.1
	Prog	4	13.5 \pm 0.7	156.8 \pm 5.3	49.4 \pm 4.5	-0.7 \pm 0.1
Circa-PHV	CT	14	14.1 \pm 0.7	163.4 \pm 5.3	52.2 \pm 8.0	0.0 \pm 0.3
	Trad	7	14.1 \pm 0.5	162.7 \pm 6.3	53.4 \pm 10.3	0.1 \pm 0.3
	Prog	10	14.2 \pm 0.5	165.1 \pm 4.4	54.4 \pm 7.7	0.0 \pm 0.2
Post-PHV	CT	8	14.7 \pm 0.7	173.3 \pm 7.2	59.2 \pm 6.7	1.3 \pm 0.4
	Trad	17	14.7 \pm 0.5	173.3 \pm 6.1	62.9 \pm 10.2	1.2 \pm 0.6
	Prog	16	14.8 \pm 0.4	172.7 \pm 5.7	66.0 \pm 8.2	1.2 \pm 0.5

Note: CT = Control group; Trad = Traditional group; Prog = Progressive group

123 Experimental procedures

124 Both the training and control groups were required to attend a pre and post-testing session, which
 125 lasted approximately 50mins each and were separated by a six-week period. Additionally, training
 126 groups participated in five training sessions lasting between 40 and 50mins each, dependent on
 127 school timetabled class durations. All sessions were performed in bare feet on a wooden
 128 gymnasium floor in self-selected active wear. A standardized warm up was led prior to each
 129 session, which lasted approximately 12mins and consisted of dynamic, progressive exercises
 130 targeting the whole body initially, then the lower limb specifically. Familiarization occurred prior to
 131 the commencement of each pre and post-test via verbal instruction and a visual demonstration.
 132 Each participant was provided the opportunity to practice each movement prior to the recorded
 133 trials.

134 The five training sessions utilised with both the traditional and progressive training groups aimed
 135 to improve sprint technique via several mechanical factors including body positioning, lower limb
 136 mechanics, upper limb mechanics, and ground contact characteristics [29–32]. The traditional and
 137 progressive coaching strategies were characterised by several key strategic differences (Table 2),
 138 with technical aspects derived from previous literature [29,33,34].

Table 2: Strategic differences of the traditional and progressive coaching styles

Traditional	Progressive
- Coach led	- Coach and athlete led
- Provided information to athlete	- Guided athletes to discover learning
- Individual feedback given to athletes	- Feedback provided through individual questioning and group discussion
- Activities and drills performed individually	- Group and pair activities used
- Focus on individual skill improvement	- Focus on group culture and interaction
- Repetition and technical focus	- Problem solving required
- No group-based competition	- Competition within group

139 Each session, the two coaches would change the group they delivered to as to ensure there was no
 140 bias towards personal delivery characteristics that may influence the PACES survey and enjoyment
 141 outcomes. Both coaches were experienced (8+ years) in coaching youth sport and were current
 142 coaches in the industry. Each coach consciously focussed on a fun and engaging delivery style
 143 which included variable tone and pitch in voice, open body-language, and a high level of energy,
 144 irrespective of whether they were with the traditional or progressive group as to ensure differences
 145 were only evident in the pre-determined coaching strategies (Table 2).

146 Data collection

147 *Anthropometrics*

148 Height, seated height and weight were measured during pre-testing to provide information for the
 149 PHV calculation [7]. Standing height was measured via a free-standing stadiometer, with the
 150 participants feet shoulder width apart and the chin and line of sight parallel to the floor. The
 151 headpiece was lowered firmly on the centre of the participants head whilst they were standing with
 152 erect posture. Seated height was measured whilst sitting on a 30cm anthropometric box placed

153 against a wall with a tape measure aligned vertically from centre of the box. Participants had their
154 legs together and hands rested on their knees. The lower back was firmly against the wall at the
155 rear of the box and the chin and eye line were parallel to the floor. The headpiece was lowered
156 firmly on to the participants head, ensuring a right angle was kept with the wall. Both standing and
157 seated heights were measured to the nearest mm. Weight was taken on a set of electronic scales
158 which were zeroed prior to each participants measurement.

159 *Sprint performance*

160 Participants performed three maximal effort 20m sprints (2mins rest between each trial), utilising a
161 standing split stance with their preferred foot placed on the starting line 0.5m back from first timing
162 light [35]. A dual-beam-modulated SWIFT timing light system (Wacol, Australia), captured
163 performance times using four sets of lights placed at the zero, 5m, 10m and 20m marks, at a height
164 of 0.85m (to top of tripod), with the lane width approximately 3m. The initial timing light gate (0m)
165 was set lower (65cm to the top of tripod) than the other gates to account for the likely hunched start
166 positions of the participants. Each trial began with a forward movement of the torso, as opposed to
167 a rocking motion where momentum could be generated prior to first foot movement. Once
168 instructed to step up to the line, the participant was free to commence the trial in their own time to
169 remove any variability in reaction times.

170 *Sprint kinematics*

171 Two high-speed cameras (Casio Exilim, ex-zr200) capturing at 240fps on fixed tripods (set at 0.8m
172 to base of tripod) were placed to capture a sagittal view perpendicular to the line of sprint. Camera
173 one was set at a 2.5m distance from the start line and 6m perpendicular to the centre of the runway,
174 which allowed the capturing of the first 5m of each sprint. Camera two was set at the 15m mark, 9m
175 perpendicular to the runway with a field of view at approximately 12.5m – 17.5m of the line of the
176 sprint. Calibration markers (1.5m in length) were placed central to both cameras to replicate similar
177 distances to those observed in comparable populations within relevant literature [36] and to
178 minimize parallax error. Data analysis of the sprint kinematics required the use of Silicon-coach pro
179 7 (Dunedin, New Zealand) to measure the following variables, with metrics derived from the
180 recommendations of [37]:

181 *Step length (m)* - Horizontal distance between the point of touchdown of one foot (furthest point)
182 and the touchdown of the following foot.

183 *Step rate (Hz)* – The amount of steps per second, calculated via the following equation, $1/(\text{stance} +$
184 $\text{flight time})$.

185 *Stance time (s)* - Duration of the time taken from the last frame before contact with the ground, to the
186 last frame with contact.

187 *Flight time (s)* - Duration of the time taken from the last frame displaying contact with the ground, to
188 the frame prior to ground contact.

189 *Unilateral horizontal jumps*

190 Maximal unilateral horizontal jump performance was obtained via three jumps for distance from
191 each leg (take-off one leg and land with two), with approximately 2mins rest between trials
192 (alternating legs each trial). Measurements were taken from the rear-most heel on a successful
193 landing. An unsuccessful landing consisted of an individual falling backwards, stepping
194 backwards, or putting their hands down behind the rear-most heel (these trials were repeated).
195 Hands were free to move throughout the movement and no coaching or technical cues were given.

196 *Tuck jump assessment*

197 A single 10s bilateral tuck jump (TJ) assessment was performed and qualitatively marked against a
198 modified rubric (Appendix A) [38]. Intra-rater reliability statistics (ICC) for the modified TJ
199 assessment was calculated at 0.971 (substantial) and a 93% PEA, with Kappa scores ranging from
200 0.615 to 1.00 ($p < 0.05$) for each of the 10 individual variables within the rubric. On the gym surface
201 where the test was to be performed, tape was used to create a box with edges 41cm in length and
202 35cm wide, which the participants were instructed to remain on if possible [38]. This assessment
203 required the participant to perform continuous tuck jumps for a period of 10s within the specified
204 area (if possible). Instructional cues consisted of the following; “bring knees to chest”, “continuous
205 jumps for 10s”, “jump as high as you feel comfortable”. Two high-speed cameras (Casio Exilim, ex-
206 zr200) capturing at 120fps on fixed tripods (set at 0.8m to base of tripod) provided frontal and
207 sagittal views of the participant during their tuck jump assessment. Scores were allocated via post-
208 session video analysis and compared against a severity based kinematic marking criteria (Appendix
209 A). It is important to note, the risk factors for injury are multifactorial, with these risk factors likely
210 to differ based on different types of injuries and sports. Although the TJ assessment provides
211 insight into several injury markers (Trunk dominance, Quadriceps dominance, Neuromuscular
212 fatigue, Leg dominance, Ligament dominance, Feedforward mechanisms deficit) it is unlikely this
213 one-off assessment will accurately predict injury risk; rather it can aid in identifying potential areas
214 to improve to decrease this risk.

215 *Paces survey*

216 Enjoyment levels for both training groups was sought through a PACES questionnaire [39], derived
217 from [40], which was administered at the completion of the final session. Instructions were to fill
218 out the survey as honestly as possible, and to take the time to read and think about each question
219 carefully.

220 *Statistical analysis*

221 A post-only spreadsheet from Hopkins [41], was utilised to analyse pre/post changes within
222 maturation levels across training groups for all performance measures and kinematic variables.
223 Differences between log-transformed measures are expressed as percentage differences, with effect
224 sizes, 90% confidence limits, p values and qualitative inferences used to supplement these changes.
225 A difference was deemed *unclear* if confidence limits of the effect statistic overlapped zero. If a
226 result was deemed as *clear*, effect sizes were awarded per the descriptors of Hopkins [42]; 0 – 0.2
227 *trivial*; 0.2 – 0.6 *small*; 0.6 – 1.2 *moderate*; 1.2 – 2.0 *large*; 2.0 – 4.0 *very large*. Statistical significance was
228 awarded for variables with a *clear* effect size and $p < 0.05$.

229 The mean of the two best sprint and horizontal jump trials was utilised for each participant and
230 used as comparative scores as per the recommendations of Maulder, Bradshaw and Keogh [43].
231 Further statistical analyses compared change scores for the 5m, 10m, and 20m sprints, as well as the
232 HJD, HJND, TJ score, and kinematic variables across maturation levels between control, traditional
233 and progressive training groups. A spreadsheet for the analysis of pre-post parallel groups' trials
234 [44], was utilised to derive net percentage changes, p values, 90% confidence limits, and effect sizes;
235 whilst qualitative descriptors were used to describe effect sizes [45]. A difference was deemed
236 unclear if confidence limits of the effect statistic overlapped zero. If a result was deemed as *clear*,
237 effect sizes were awarded per the descriptors of Hopkins [42]; 0 – 0.2 *trivial*; 0.2 – 0.6 *small*; 0.6 – 1.2
238 *moderate*; 1.2 – 2.0 *large*; 2.0 – 4.0 *very large*. Statistical significance was awarded for variables with a
239 *clear* effect size and $p < 0.05$.

240 The PACES enjoyment survey was analysed via a spreadsheet comparing group means [46]. This
241 provided mean and standard deviations for both training groups accompanied by p values and
242 effect sizes to interpret the magnitude of difference [42].

243 3. Results

244 *Anthropometrics and performance measures*

245 Pre and post-test mean and SD for sprint and jump metrics can be found in Tables 3 and 4. Log-
246 transformed within-group differences and between-group differences can be observed in Tables 5
247 and 6, and 7 and 8, respectively.

248 Pre-testing data identified that there were no significant differences ($p > 0.05$) between training-
249 groups of the same maturation level prior to intervention. It was observed that height, weight and
250 seated height increased significantly for all training groups ($p < 0.05$) over the five-week intervention
251 without maturational grouping. The exception to this was the control-group seated height which
252 had a non-significant trivial-small increase ($0.4\% \pm 90\%CL = 0.9\%$; $p = 0.479$). Maturational grouping
253 displayed that the pre PHV and circa-PHV groups significantly increased height, weight and seated
254 height ($p < 0.05$) during the intervention period, with the post-PHV group showing significant
255 differences in height ($0.9\% \pm 0.7\%$, $p = 0.035$) and weight ($2.2\% \pm 0.8\%$, $p < 0.001$) only.

256 When comparing pre/post change scores, it was revealed that small-large significant differences in
257 TJ scores between the control and progressive-groups ($p = 0.018$) were evident. No significant
258 differences were observed for any anthropometric, sprint or horizontal jump measures when
259 maturation was utilised as a covariate and compared across training-groups (see Tables 7 and 8).
260 Despite being non-significant, clear outcomes were identified for many performance-based metrics.

261 When comparing strictly pre-PHV means between training-groups, clear outcomes were identified
262 for the progressive-group who displayed the largest change in mean 5m ($-2.1\% \pm 2.9\%$, $p = 0.080$),
263 10m ($-1.1\% \pm 2.7\%$, $p = 0.395$), and 20m ($-2.7\% \pm 3.2\%$, $p = 0.136$) sprint times, with effect sizes
264 ranging from trivial to moderate (see Table 5). Group sprint means (5m, 10m, and 20m) for both the
265 traditional and control pre-PHV groups were up to 4.4% slower when compared to pre-assessment
266 times (see Table 5). This trend continued within the jump data, with the progressive-group pre-
267 PHV eliciting trivial to large improvements in HJD ($10.8\% \pm 10.7$, $p = 0.098$), HJND ($11.0\% \pm 6.2\%$, p
268 $= 0.027$) performances (see Table 4). Despite traditional and control-groups also eliciting positive
269 jump performances (4.3% to 7.6%) effect sizes were unclear – moderate and statistically non-
270 significant ($p > 0.05$). Contrasting to these results, pre-PHV tuck jump scores showed the largest
271 deterioration within the progressive-group ($25.8\% \pm 22\%$, $p = 0.073$), with the traditional and
272 control-groups improving their scores by $15.6\% \pm 84.9\%$ ($p = 0.547$), and $11\% \pm 49.7\%$ ($p = 0.506$),
273 respectively (see Table 4 and 6).

274 When comparing circa-PHV groups, decreased sprint times were observed in each of the 5m, 10m,
275 and 20m distances across all training-groups with mean improvements of -0.1% to -3.1% (see Tables
276 3 and 5). The circa-PHV progressive ($-1.6\% \pm 1.2\%$, $p = 0.043$) and control ($-2.2\% \pm 1.7\%$, $p = 0.036$)
277 20m sprint times were the only statistically significant improvements in sprint times, both with
278 trivial to small effect sizes. Although non-significant, the traditional-group elicited the greatest
279 improvements in circa-PHV HJD ($10.1\% \pm 4.9\%$, $p = 0.008$), and HJND ($9.9\% \pm 8.2\%$, $p = 0.060$)
280 scores, but as seen in the pre-PHV groups, the training-group who witnessed the greatest gains in
281 horizontal jump distance also displayed the greatest deterioration in TJ score ($14.2\% \pm 29.1\%$, $p =$
282 0.350), in contrast to the control group who improved by $8.9\% \pm 13.4$ ($p = 0.213$) (see Table 6).

283 When comparing post-PHV change scores, unclear results were identified for all training-groups
284 for 5m sprint times, with pre/post change scores ranging from -0.9% to 0.7% . Post-PHV 10m sprint
285 times displayed trivial to moderate improvements for the traditional ($-2.1\% \pm 2.7$, $p = 0.177$) and
286 control ($-0.9\% \pm 1.7\%$, $p = 0.321$) groups, with the progressive-group slowing by $0.6\% \pm 1.6\%$ ($p =$
287 0.538). Significant improvements were identified in control ($p = 0.028$) and traditional ($p = 0.030$)
288 20m sprint times, with the progressive-group improving by a non-significant $-0.3\% \pm 1.9\%$ ($p =$

289 0.748). All HJD and HJND performances improved significantly ($p < 0.05$) between 3.8% and 9.3% at
290 the post-PHV level across all training groups, with all TJ scores increasing between 1.9% and 12.9%
291 (see Tables 4 and 6).

292 When removing maturation as the covariate and observing training groups in their entirety, there
293 were significant changes for several sprint and jump performance measures. Trivial to small
294 improvements were seen in the control ($-1.8\% \pm 1.1\%$, $p = 0.008$), and traditional ($-1.8\% \pm 1.1\%$, $p =$
295 0.008) 20m sprint times, as well as small to moderate improvements in HJD and HJND
296 performances for all training groups, irrespective of maturational grouping ($p < 0.05$) (see Tables 4
297 and 6).

298 Kinematic measures

299 Whilst incorporating maturation and comparing training-group kinematic characteristics, there
300 were several significant changes within the circa and post-groups, with no significant ($p > 0.05$)
301 differences between training-group kinematic variables at the pre-PHV level (see Appendix B).

302 The circa-PHV progressive-group measures displayed significantly larger 15m flight times ($14.3\% \pm$
303 8.9% , $p = 0.015$), and significantly lower step frequencies at the second-step ($9.5\% \pm 8.0\%$, $p = 0.036$)
304 and 15m-step ($9.8\% \pm 7.8$, $p = 0.028$) when compared to the circa-PHV control-group (see Appendix
305 B). During step-two, the circa-PHV control group displayed an increase in step-length ($7.7\% \pm 6.1\%$,
306 $p = 0.038$) and shorter flight time during step-one ($-34.3\% \pm 22.8\%$, $p = 0.026$) when compared to the
307 traditional-group change scores. Significant ($p < 0.05$) small-large effect sizes were identified between
308 the circa-PHV traditional and progressive contact times at step-two ($9.3\% \pm 6.9\%$) and 15m ($7.7\% \pm$
309 5.3%), as well as step-frequency during step-two ($8.8\% \pm 6.5\%$) (see Appendix B).

310 Comparing between groups at the post-PHV level, control-groups displayed trivial-moderate
311 longer step length during step-two ($p = 0.039$) and three ($p = 0.041$) when compared to both
312 progressive and traditional-groups, respectively (see Appendix B). The post-PHV control-group
313 also displayed a shorter contact time during step-one ($-6.9\% \pm 5.5\%$, $p = 0.031$) when compared to
314 progressive-group, and a lower step frequency during step-one ($13.7\% \pm 8.1\%$, $p = 0.010$) when
315 compared to traditional group. The post-PHV traditional-group displayed a trivial to moderate
316 difference in step-one step-length, in comparison to the progressive-group ($p = 0.045$).

317 When maturation was removed as a covariate and training-groups were analysed in their entirety,
318 significant differences in step frequency were observed between control and traditional-groups
319 during step-one ($p = 0.032$). It was also determined that the traditional-group had a significantly
320 faster contact time at the 15m mark ($-5.4\% \pm 3.7\%$, $p = 0.018$) than the progressive-group.

321 Despite being non-significantly different to improvements witnessed in other training-groups,
322 pre/post comparisons revealed the control-group had a significant increase in step 2 step-length
323 ($4.7\% \pm 2.1\%$, $p = 0.001$), accompanied by a trivial to moderate increase in contact time during step-
324 one ($0.217\text{s} - 0.224\text{s}$, $p = 0.025$).

325 Significant decreases were observed in traditional-group contact time ($p = 0.001$, ES = small-
326 moderate) and flight time ($p = 0.019$, ES = trivial-small) at the 15m recording, with mean changes
327 ranging from -5.8% to -7% for both of the observed metrics.

328 The progressive group significantly increased mean 15m flight time ($0.091\text{s} - 0.098\text{s}$, $p = 0.029$, ES =
329 trivial-moderate) and 15m step length ($1.70\text{m} - 1.75\text{m}$, $p = 0.023$, ES = trivial-small), over the course
330 of the intervention.

331 The PACES enjoyment survey revealed no significant differences within maturation and coaching
332 groups ($p > 0.05$), with mean scores ranging from 49.7 to 61.4. The circa-PHV group displayed the

333 only clear difference between traditional and progressive coaching methods, with the progressive
 334 being identified as more enjoyable with a trivial-large effect size ($p = 0.090$).3.2.

Table 3: Pre and post sprint mean \pm SD for training and maturation groups

Metric	Maturatio n group	Test	Control		Traditional		Progressive	
			Mean	\pm SD	Mean	\pm SD	Mean	\pm SD
5m (s)	All	Pre	1.16	\pm 0.08	1.15	\pm 0.07	1.16	\pm 0.08
		Post	1.16	\pm 0.08	1.15	\pm 0.07	1.16	\pm 0.07
	Pre-PHV	Pre	1.15	\pm 0.04	1.17	\pm 0.05	1.21	\pm 0.07
		Post	1.18	\pm 0.05	1.22	\pm 0.06	1.18	\pm 0.08
	Circa-PHV	Pre	1.18	\pm 0.09	1.19	\pm 0.10	1.18	\pm 0.05
		Post	1.18	\pm 0.09	1.18	\pm 0.06	1.18	\pm 0.05
Post-PHV	Pre	1.13	\pm 0.04	1.12	\pm 0.05	1.14	\pm 0.10	
	Post	1.12	\pm 0.07	1.12	\pm 0.06	1.15	\pm 0.09	
10m (s)	All	Pre	2.01	\pm 0.13	1.98	\pm 0.14	2.00	\pm 0.15
		Post	1.99	\pm 0.17	1.95	\pm 0.15	1.98	\pm 0.14
	Pre-PHV	Pre	1.98	\pm 0.04	2.07	\pm 0.09	2.07	\pm 0.14
		Post	2.02	\pm 0.06	2.11	\pm 0.09	2.05	\pm 0.12
	Circa-PHV	Pre	2.05	\pm 0.16	2.04	\pm 0.20	2.03	\pm 0.09
		Post	2.02	\pm 0.14	2.00	\pm 0.11	1.98	\pm 0.19
Post-PHV	Pre	1.95	\pm 0.07	1.93	\pm 0.10	1.96	\pm 0.18	
	Post	1.93	\pm 0.10	1.89	\pm 0.14	1.97	\pm 0.17	
20m (s)	All	Pre	3.52	\pm 0.26	3.46	\pm 0.28	3.49	\pm 0.30
		Post	3.45	\pm 0.23*	3.40	\pm 0.23*	3.46	\pm 0.27
	Pre-PHV	Pre	3.47	\pm 0.04	3.70	\pm 0.22	3.66	\pm 0.29
		Post	3.50	\pm 0.09	3.70	\pm 0.15	3.56	\pm 0.20
	Circa-PHV	Pre	3.60	\pm 0.30	3.57	\pm 0.37	3.55	\pm 0.19
		Post	3.52	\pm 0.26*	3.45	\pm 0.22	3.49	\pm 0.16*
Post-PHV	Pre	3.40	\pm 0.15	3.37	\pm 0.20	3.42	\pm 0.35	
	Post	3.33	\pm 0.18*	3.31	\pm 0.19*	3.41	\pm 0.34	

Note: * = significantly different to pre-test ($p < 0.05$).

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Table 4: Pre and post jump mean \pm SD for training and maturation groups

Metric	Maturation group	Test	Control		Traditional		Progressive		
			Mean	± SD	Mean	± SD	Mean	± SD	
HJD (m)	All	Pre	1.55	± 0.21	1.65	± 0.18	1.59	± 0.25	
		Post	1.65	± 0.22*	1.74	± 0.18*	1.70	± 0.23*	
	Pre-PHV	Pre	1.55	± 0.12	1.50	± 0.15	1.46	± 0.17	
		Post	1.63	± 0.16	1.61	± 0.08	1.61	± 0.08	
	Circa-PHV	Pre	1.54	± 0.24	1.57	± 0.20	1.60	± 0.23	
		Post	1.62	± 0.26	1.72	± 0.20*	1.68	± 0.14	
	Post-PHV	Pre	1.59	± 0.19	1.71	± 0.14	1.63	± 0.28	
		Post	1.73	± 0.14*	1.78	± 0.17*	1.73	± 0.30	
	HJND (m)	All	Pre	1.48	± 0.21	1.58	± 0.17	1.52	± 0.25
			Post	1.56	± 0.22*	1.66	± 0.18*	1.63	± 0.24*
Pre-PHV		Pre	1.45	± 0.14	1.48	± 0.15	1.41	± 0.12	
		Post	1.51	± 0.11	1.54	± 0.09	1.56	± 0.08*	
Circa-PHV		Pre	1.46	± 0.24	1.48	± 0.19	1.50	± 0.22	
		Post	1.52	± 0.26	1.62	± 0.20	1.60	± 0.16	
Post-PHV		Pre	1.53	± 0.20	1.64	± 0.14	1.56	± 0.29	
		Post	1.65	± 0.14*	1.71	± 0.18*	1.66	± 0.31	
TJ Score		All	Pre	13.9	± 2.6	11.6	± 3.0	12.0	± 2.9
			Post	13.1	± 2.8	12.4	± 3.0	13.5	± 2.7*
	Pre-PHV	Pre	15.0	± 3.0	13.0	± 0.8	11.8	± 1.5	
		Post	12.7	± 2.5	12.0	± 3.4	14.8	± 1.5	
	Circa-PHV	Pre	13.8	± 2.1	12.4	± 3.0	11.5	± 3.2	
		Post	12.6	± 2.4	14.1	± 3.1	12.7	± 3.6	
	Post-PHV	Pre	13.8	± 3.5	11.0	± 3.2	12.1	± 2.9	
		Post	14.1	± 3.6	11.8	± 2.8	13.5	± 2.1	

Note: * = significantly different to pre-test ($p < 0.05$).

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Table 5: Percentage change (90%CL) in sprint metrics within maturational groups across control, traditional and progressive training groups

Metric	Maturation	Control		Traditional		Progressive	
		%diff, ± CL	(ES, ± CL)	%diff, ± CL	(ES, ± CL)	%diff, ± CL	(ES, ± CL)
5m (s)	All	0.0, ± 1.5	(-0.01, ± 0.22)	0.1, ± 1.4	(0.02, ± 0.21)	0.1, ± 1.1	(0.01 ± 0.16)
	Pre-PHV	3.3, ± 10.4	(0.57, ± 1.72)	4.4, ± 5.2	(0.70, ± 0.83)	-2.1, ± 2.9	(-0.27 ± 0.37)
	Circa-PHV	-0.3, ± 2.0	(-0.03, ± 0.25)	-1.1, ± 3.3	(-0.11, ± 0.35)	-0.1, ± 1.9	(-0.03 ± 0.39)
	Post-PHV	-0.9, ± 2.4	(-0.24, ± 0.62)	-0.4, ± 1.6	(-0.07, ± 0.30)	0.7, ± 1.7	(0.09 ± 0.20)
10m (s)	All	-0.7, ± 1.1	(-0.10, ± 0.17)	-1.4, ± 1.8	(-0.20, ± 0.26)	-0.7, ± 1.6	(-0.10 ± 0.21)
	Pre-PHV	2.0, ± 6.6	(0.60, ± 1.91)	2.0, ± 3.2	(0.32, ± 0.51)	-1.1, ± 2.7	(-0.12 ± 0.30)
	Circa-PHV	-1.1, ± 1.6	(-0.13, ± 0.20)	-1.5, ± 3.3	(-0.14, ± 0.30)	-2.6, ± 4.4	(-0.55 ± 0.89)
	Post-PHV	-0.9, ± 1.7	(-0.24, ± 0.42)	-2.1, ± 2.7	(-0.41, ± 0.51)	0.6, ± 1.6	(0.06 ± 0.18)
20m (s)	All	-1.8, ± 1.1	(-0.25, ± 0.15)*	-1.8, ± 1.1	(-0.23, ± 0.13)*	-1.1, ± 1.1	(-0.12 ± 0.13)
	Pre-PHV	0.8, ± 5.0	(0.40, ± 2.33)	0.0, ± 3.4	(0.00, ± 0.41)	-2.7, ± 3.2	(-0.25 ± 0.29)
	Circa-PHV	-2.2, ± 1.7	(-0.26, ± 0.19)*	-3.1, ± 3.3	(-0.27, ± 0.28)	-1.6, ± 1.2	(-0.27 ± 1.21)*
	Post-PHV	-2.1, ± 1.5	(-0.43, ± 0.30)*	-1.7, ± 1.2	(-0.28, ± 0.20)*	-0.3, ± 1.9	(-0.03 ± 0.19)

Note: %diff = percentage difference in means; CL = 90% confidence limits; ES = effect size; * = significant difference in pre/post means ($p < 0.05$).

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Table 6: Percentage change (90%CL) in jump metrics within maturational groups across control, traditional and progressive training groups

Metric	Maturation	Control		Traditional		Progressive	
		%diff, ± CL	(ES, ± CL)	%diff, ± CL	(ES, ± CL)	%diff, ± CL	(ES, ± CL)
HJD	All	6.4, ± 3.0	(0.43, ± 0.20)*	6.0, ± 2.1	(0.52, ± 0.19)*	6.7, ± 2.0	(0.41, ± 0.13)*
	Pre-PHV	4.8, ± 5.9	(0.34, ± 0.42)	7.6, ± 7.5	(0.50, ± 0.50)	10.8, ± 10.7	(0.63, ± 0.62)
	Circa-PHV	5.1, ± 4.5	(0.29, ± 0.26)	10.1, ± 4.9	(0.64, ± 0.32)*	5.4, ± 4.6	(0.36, ± 0.30)
	Post-PHV	9.3, ± 5.8	(0.63, ± 0.40)*	4.0, ± 2.7	(0.45, ± 0.30)*	6.5, ± 2.2	(0.35, ± 0.12)*
HJND	All	5.6, ± 2.9	(0.35, ± 0.18)*	5.4, ± 2.6	(0.45, ± 0.22)*	7.2, ± 2.1	(0.41, ± 0.12)*
	Pre-PHV	4.3, ± 11.3	(0.25, ± 0.63)	4.3, ± 7.9	(0.29, ± 0.53)	11.0, ± 6.2	(0.85, ± 0.49)*
	Circa-PHV	4.2, ± 3.8	(0.22, ± 0.20)	9.9, ± 8.2	(0.60, ± 0.50)	7.3, ± 5.9	(0.45, ± 0.37)
	Post-PHV	8.5, ± 6.5	(0.55, ± 0.43)*	3.8, ± 2.9	(0.42, ± 0.32)*	6.2, ± 2.1	(0.30, ± 0.10)*
TJ Score	All	-6.4, ± 12.3	(-0.35, ± 0.61)	6.8, ± 9.9	(0.23, ± 0.33)	13.1, ± 8.0	(0.47, ± 0.29)*
	Pre-PHV	-15.6, ± 84.9	(-0.48, ± 1.73)	-11.0, ± 49.7	(-1.34, ± 4.66)	25.8, ± 22.0	(1.29, ± 1.11)
	Circa-PHV	-8.9, ± 13.4	(-0.60, ± 0.81)	14.2, ± 29.1	(0.46, ± 0.89)	10.2, ± 20.8	(0.30, ± 0.59)
	Post-PHV	1.9, ± 36.1	(0.07, ± 1.09)	8.4, ± 11.7	(0.25, ± 0.35)	12.9, ± 10.4	(0.45, ± 0.37)*

Note: %diff = percentage difference in means; CL = 90% confidence limits; ES = effect size; * = significant difference in pre/post means ($p < 0.05$); HJD = Horizontal jump dominant leg; HJND = Horizontal jump non-dominant leg.

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Table 7: Percentage difference (90%CL) in sprint change scores within maturation groups and between training groups

Metric	Maturation	Control vs Traditional		Control vs Progressive		Traditional vs Progressive	
		%diff, ± CL	(ES, ± CL)	%diff, ± CL	(ES, ± CL)	%diff, ± CL	(ES, ± CL)
5m (s)	All	0.4, ± 2.1	(0.07, ± 0.35)	0.2, ± 1.9	(0.03, ± 0.27)	0.0, ± 1.9	(0.00, ± 0.27)
	Pre-PHV	1.0, ± 9.9	(0.23, ± 2.14)	-5.3, ± 11.1	(-0.90, ± 1.75)	-6.2, ± 5.4	(-1.14, ± 0.94)
	Circa-PHV	-0.8, ± 3.7	(-0.10, ± 0.46)	0.1, ± 2.7	(0.02, ± 0.40)	-0.8, ± 3.7	(-0.10, ± 0.56)
	Post-PHV	0.5, ± 2.7	(0.12, ± 0.59)	1.6, ± 2.8	(0.23, ± 0.39)	1.1, ± 2.3	(0.16, ± 0.33)
10m (s)	All	-0.9, ± 2.5	(-0.14, ± 0.45)	-0.2, ± 2.4	(-0.03, ± 0.33)	0.5, ± 2.8	(0.07, ± 0.37)
	Pre-PHV	0.0, ± 6.2	(0.00, ± 1.30)	-3.1, ± 6.0	(-0.51, ± 0.95)	-3.1, ± 3.6	(-0.53, ± 0.60)
	Circa-PHV	-0.4, ± 3.5	(-0.05, ± 0.42)	-1.6, ± 4.7	(-0.24, ± 0.69)	-0.4, ± 3.5	(-0.05, ± 0.74)
	Post-PHV	-1.2, ± 3.0	(-0.26, ± 0.65)	1.5, ± 2.2	(0.20, ± 0.29)	2.7, ± 3.0	(0.38, ± 0.43)
20m (s)	All	0.4, ± 1.5	(0.06, ± 0.21)	1.0, ± 1.8	(0.12, ± 0.21)	0.9, ± 1.8	(0.11, ± 0.21)
	Pre-PHV	-0.9, ± 4.8	(-0.14, ± 0.75)	-3.5, ± 4.7	(-0.49, ± 0.63)	-2.9, ± 4.2	(-0.11, ± 0.15)
	Circa-PHV	-0.9, ± 3.6	(-0.10, ± 0.39)	0.7, ± 2.0	(0.09, ± 0.28)	-0.9, ± 3.6	(-0.10, ± 0.45)
	Post-PHV	0.4, ± 1.8	(0.07, ± 0.33)	1.7, ± 2.3	(0.21, ± 0.27)	1.3, ± 2.2	(0.17, ± 0.27)

Note: %diff = percentage difference in means; CL = 90% confidence limits; ES = effect size;

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Table 8: Percentage difference (90%CL) in jump change scores within maturation groups and between training groups

Metric	Maturation	Control vs Traditional		Control vs Progressive			Traditional vs Progressive		
		%diff, ± CL	(ES, ± CL)	%diff, ± CL	(ES, ± CL)	%diff, ± CL	(ES, ± CL)		
HJD	All	-1.4, ± 3.8	(-0.11, ± 0.29)	0.8, ± 3.6	(0.05, ± 0.23)	1.1, ± 2.9	(0.08, ± 0.21)		
	Pre-PHV	2.6, ± 8.1	(0.25, ± 0.76)	5.7, ± 10.6	(0.47, ± 0.86)	3.0, ± 11.2	(0.25, ± 0.90)		
	Circa-PHV	4.8, ± 6.3	(0.31, ± 0.40)	0.4, ± 6.2	(0.02, ± 0.39)	-4.2, ± 6.3	(-0.32, ± 0.45)		
	Post-PHV	-4.8, ± 6.3	(-0.46, ± 0.57)	-2.5, ± 6.1	(-0.16, ± 0.37)	2.4, ± 3.4	(0.17, ± 0.27)		
HJND	All	-1.6, ± 3.8	(-0.11, ± 0.27)	1.6, ± 3.3	(0.09, ± 0.20)	1.8, ± 3.1	(0.12, ± 0.21)		
	Pre-PHV	0.0, ± 11.0	(0.00, ± 0.97)	6.4, ± 11.1	(0.63, ± 1.07)	6.4, ± 8.7	(0.59, ± 0.79)		
	Circa-PHV	5.4, ± 8.8	(0.32, ± 0.51)	2.9, ± 6.8	(0.18, ± 0.40)	-2.3, ± 9.5	(-0.17, ± 0.64)		
	Post-PHV	-4.3, ± 7.0	(-0.40, ± 0.62)	-2.1, ± 6.8	(-0.12, ± 0.37)	2.3, ± 3.5	(0.15, ± 0.23)		
TJ Score	All	9.6, ± 16.6	(1.35, ± 0.58)	22.8, ± 15.1	(0.86, ± 0.59)*	7.7, ± 13.2	(0.27, ± 0.45)		
	Pre-PHV	5.4, ± 78.4	(0.32, ± 3.50)	49.0, ± 94.0	(1.77, ± 2.95)	41.3, ± 50.3	(2.79, ± 3.29)		
	Circa-PHV	25.4, ± 31.5	(1.14, ± 1.39)	20.9, ± 24.4	(0.77, ± 0.88)	-3.5, ± 34.7	(-0.13, ± 1.04)		
	Post-PHV	6.3, ± 37.7	(0.19, ± 1.02)	9.9, ± 37.5	(0.35, ± 1.19)	3.3, ± 15.0	(0.11, ± 0.47)		

Note: * = significant difference between training groups ($p < 0.05$); %diff = percentage difference in means; CL = 90% confidence limits; ES = effect size; HJD = Horizontal jump dominant leg; HJND = Horizontal jump non-dominant leg

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360 Discussion

361 The purpose of this study was to compare the effects of a progressive and traditional coaching style
362 on sprint and jump performance within varying levels of maturation. Previous literature informed
363 the hypothesis that the progressive-group would elicit the greatest sprint and jump improvements
364 for the pre and post-PHV groups, in conjunction with a decrease in injury markers. Based on the
365 phenomenon termed 'adolescent awkwardness', the circa-PHV group was hypothesised to respond
366 best to the traditional style of coaching; whilst enjoyment would be consistent between traditional
367 and progressive groups regardless of maturation. As hypothesised, the results of this study
368 revealed that although non-significant ($p>0.05$), different coaching modalities may elicit superior
369 improvements in sprint and jump performances if delivered to those of the appropriate physical
370 and neurological maturation; however, increases in performances requiring high force generation
371 may correspond with a heightened risk of injury.

372 *The effects of progressive and traditional coaching strategies on pre-PHV groups:*

373 The progressive coaching style promoted the greatest improvements in 5m ($-2.1\% \pm 2.9\%$), 10m ($-$
374 $1.1\% \pm 2.7\%$), and 20m ($-2.7\% \pm 3.2\%$) sprint times, and both horizontal jump performances (HJD
375 ($10.8\% \pm 10.7$), HJND ($11.0\% \pm 6.2\%$)), when compared to the traditional and control groups (see
376 Tables 5 & 6). This indicates this method of coaching may in fact benefit the pre-PHV maturation-
377 group more-so than other styles if performance is the desired outcome. This finding supports both
378 the hypothesis of the current study and relevant literature surrounding the underlying methods
379 incorporated within the progressive coaching style [16,20,21,47]. A meta-analysis completed by
380 Moran, Sandercock, Rumpf and Parry [48], investigated sprint enhancement with respect to
381 maturation and describes how improvements in pre-PHV sprint performances are typically
382 restricted due to the limitations surrounding muscular strength, neuromuscular control and
383 anthropometric factors. The current study produced dissimilar findings to these, and although
384 results are non-significant, suggest appropriate coaching strategies may produce viable sprint
385 training opportunities within the pre-PHV population. The disparities between the meta-analysis
386 performed by Moran, Sandercock, Rumpf and Parry [48] and the current study lie within the style
387 of intervention, and the population tested. Inclusion for the study by Moran et al., [48], required
388 sprinting-based movements with a specific recovery period and utilised participants who were
389 engaged in organised sport. In contrast, the current study used sub-maximal fundamental sprint
390 mechanics as the training intervention aimed at altering technique, within a general population of
391 individuals. These factors may be critical in identifying when and how to target sprint training
392 within the pre-PHV population.

393 When investigating the mechanisms behind the sprint improvements, previous research has
394 identified that improved sprint times involve increases in step length and/or step frequency
395 without negatively effecting the other [49,50]. Kinematic analysis of the pre-PHV progressive group
396 means supported these statements as increases ($p>0.05$) in step length were evident, with little
397 variation in step frequency when compared to pre-test measures (see Appendix B). Previous
398 literature has linked a longer step length to increases in standing height and limb length [1,27], both
399 of which increased significantly ($p<0.05$) within all the pre-PHV groups over the period of the
400 intervention. These anthropometric variations begin to provide a plausible mechanism for the
401 altered kinematics; however, it is important to note the traditional and control groups also exhibited
402 these anthropometric trends, but unlike the progressive group, these did not transpire to improved
403 step length and/or frequency. This conclusion acknowledges the plausibility of the successful
404 application of the progressive coaching sessions, which focussed on key sprint mechanics and
405 movement efficiency ultimately refining and synchronising movement patterns more-so than the
406 traditional or control groups [29,34,48]. The ability to coordinate the sequencing of multiple limb
407 segments, synchronise motor unit recruitment, and increase the number of motor units utilised, has

408 been shown to produce greater muscular force output [31,51]. These physiological and neural
409 adaptations can be gained through muscular overload and high velocity muscular activation
410 [52,53], with the latter a specific element included in the training programmes utilised within this
411 study. Supporting this hypothesis, the HJD and HJND displayed significant increases in jump
412 distance, which illustrates a likely increase in lower limb power [54–56], which has been shown to
413 be an important factor in improving sprint performance [57,58]. It is unwise to state that improved
414 lower limb power via neural activation, or neuromuscular adaptation, is a leading cause of
415 performance and kinematic improvements in the current study due to the lack of specific
416 measurements of these variables; however, due to the short duration and power-based tests
417 performed, it is a conclusion worth considering.

418 This notion of increased muscular output is further supported by the findings in the pre-PHV tuck
419 jump scores, which showed the largest decrement in the progressive group, suggesting they have
420 an increased risk of injury post-intervention. The need to safely control and decelerate limbs via
421 eccentric contractions is vital to injury management, and can be exasperated during periods of
422 increased force production [59,60]. This process requires an element of technical control and
423 muscular strength, neither of which were targeted within the coaching sessions of this intervention.
424 These findings suggest the improvements in sprint and jump performances witnessed within the
425 pre-PHV group were accompanied by a decreased ability to safely control the underlying
426 mechanisms responsible for these improvements. This finding is critical in the long term safety of
427 athletes, as previous research has already identified a higher injury rate for individuals around the
428 period of PHV [8,61–63]. Future interventions pursuing sprint and jump improvements should
429 consider eccentric, plyometric and/or other strengthening interventions to supplement their sprint
430 and jumps training to not only increase the performance response, but to provide the technical and
431 physical proficiency required to safely accommodate the physiological changes that occur during
432 this process [25,54,64].

433 *The effects of progressive and traditional coaching strategies on circa-PHV groups:*

434 Based on the data collected it is ill-advised to state the circa-PHV group responded more effectively
435 to any one of the training methods utilised within this study, therefore proving the initial
436 hypothesis to be incorrect. Despite the lack of significant findings, the circa-PHV traditional group
437 displayed the greatest improvements in 5m ($-1.1\% \pm 3.3\%$) and 20m ($-3.1\% \pm 3.3\%$) sprint times, as
438 well as both the horizontal jump distances. This trend may begin to reveal an underlying need to
439 adjust coaching strategies between levels of maturation. The traditional approach incorporated
440 direct, individual feedback, as opposed to the previously successful questioning and problem-
441 solving methods used within the progressive style of coaching [16,20,21,47]. The poorly understood,
442 yet frequently acknowledged phenomenon termed adolescent awkwardness [1,65,66], may be
443 influential in explaining why the traditional training was successful within the circa-PHV
444 population. Adolescent awkwardness occurs during the adolescent growth phase and is
445 characterised by rapid long-bone growth prior to muscular development which may correspond
446 with a period of disruption in motor coordination [3,66]. Clear, direct, and individual instructions
447 such as those utilised in the traditional coaching method, may help to produce a more effective
448 movement output [67,68], or minimise the supposed disconnect between the brain and body during
449 the adolescent growth spurt more-so than the strategies observed within the progressive coaching
450 style.

451 When analysing sprint metrics, all circa-groups improved each of the 5m, 10m and 20m sprint
452 times, albeit insignificantly for the majority (see Table 7). Kinematic variables associated with these
453 sprint performances show the traditional and control groups displaying non-significant ($p>0.05$)
454 increases in most step length and step frequency measures, which supports the findings of past
455 sprint literature [37,49,50]. This tendency proved inconsistent within the progressive group who
456 increased step length in all measured ground contacts, but also saw a decrease in step frequency

457 throughout. These discoveries propose this decrease in step frequency was not enough to inversely
458 effect the performance gains achieved through the increased step length, or inform that there were
459 other factors at play outside of this studies measured variables [50,69]. As discussed, the kinematic
460 variations across groups are likely influenced by the significant increases ($p<0.05$) in standing
461 height, weight and seated height observed for all the circa-PHV groups as a natural response of
462 maturation [1,27]. It is important to acknowledge there are likely factors external to the study
463 design that were influential to sprint results within this population. It is hypothesised that varying
464 levels of cognitive focus, fatigue and motivation [70,71], movement experience gained through
465 incidental exercise or regular physical education classes, or neuromuscular maturation may have
466 influenced overall findings [72,73].

467 As observed within the pre-PHV findings, the training approach that generated the greatest sprint
468 and jump improvements within the circa-PHV population, also produced the greatest increase in
469 injury markers during the tuck jump assessment. This trend has been hypothesised to be attributed
470 to increases in concentric power, segment sequencing and/or the inability to accommodate the
471 increases in these physiological alterations. To counter these initial statements, the control group
472 improved their tuck jump score by 8.9%, which implies they are at a decreased risk of injury than
473 their pre-test; however, they also improved each of their sprint times, which suggests the
474 mechanism behind these variations is still unclear and requires further investigation. It is
475 recommended this test is utilised with caution until the underlying causes of these changes are
476 identified within this population [74].

477 *The effects of progressive and traditional coaching strategies on post-PHV groups:*

478 As discussed previously, the lack of significant group differences within maturation suggests
479 minimal differences between coaching strategies and sprint performances. Despite this, the control
480 post-PHV group elicited the greatest improvements in 5m and 20m sprint times, as well as both
481 horizontal jump distances and tuck jump scores (see Tables 5 & 6). These results counter the initial
482 hypothesis of this paper and suggest neither of the training groups were able to generate
483 performance benefits greater than those achieved through natural maturation, rendering the
484 training intervention ineffective within this population. Biological maturation within the post-PHV
485 includes hormonal, physical, neurological and physiological adaptations that result in a greater
486 muscle mass, increased long bone length, and neural enhancement which lead to natural
487 improvements in some motor tasks [1,27] and also sprint performance [48]. These statements are
488 supported by control groups producing comparable improvements in sprint performances to those
489 observed in both training groups, accompanied by significant increases ($p<0.05$) in standing height
490 and weight. Despite these increases, step length and step frequency displayed irregular but similar
491 changes through all training and control groups; therefore, suggesting their influence on sprint
492 performance was limited within this cohort [37,49,50]. Probable justifications for these increases in
493 sprint times and horizontal jump performances include refined neuromuscular coordination,
494 increases in muscular output and/or greater mechanical efficiency [31,51], although without direct
495 measures of these variables it is difficult to conclude.

496 Based on the findings of the current study, technical training utilising traditional or progressive
497 coaching methods is not sufficient to elicit responses greater than those achieved through natural
498 maturation, and therefore trainers and coaches working with individuals of post-PHV maturation
499 should employ appropriate physical interventions alongside technical training of various nature to
500 maximise motor improvements. As per the recommendations of [2] and [72] interventions targeting
501 plyometric and resistance training exercises may elicit responses within the post-PHV maturation
502 group than movement-based coaching alone. It is important to note coaches working with
503 adolescent athletes need to acknowledge the impact of physical and neurological maturation when
504 comparing performances, or pre/post testing in sporting contexts, especially if it is to provide a

505 measure of training effectiveness for new athletes as these improvements may in fact be due to
506 natural maturation and not as a consequence of training strategies.

507 *Collective group findings:*

508 When comparing training groups within maturation levels, there were no significant differences
509 ($p < 0.05$) in pre/post change scores between training groups and control groups. It is hypothesised
510 these findings may be due to the lack of statistical power from low participant numbers within the
511 pre-PHV group and the overall variance witnessed due to the general population utilised within
512 this study.

513 As hypothesised, enjoyment played a limited role when it came to training group selection, as
514 results proved there were no significant differences ($p > 0.05$) within maturation levels. Mean scores
515 ranged from 49.7 to 61.4 points (out of a maximum of 80), suggesting that there was an adequate
516 level of enjoyment through each training modality; therefore, over a five-week period either
517 strategy is appropriate from an enjoyment perspective and performance gains will provide
518 justification for using one approach over the other.

519 *Limitations and future recommendations:*

520 Primary limitations of this study include low participant numbers within the pre-PHV groups. This
521 was due to the age of the high school students utilised and the need to break a small pre-PHV
522 cohort into three different experimental groups. Despite this, training groups within pre-PHV
523 maturation were of similar size, allowing a more consistent statistical approach to be applied.
524 Future research should utilise a slightly younger cohort to provide greater pre-PHV numbers and
525 improve the statistical strength of the analysis. Secondly, the PHV equation used to separate
526 maturation groups as presented by Mirwald, Baxter-Jones, Bailey and Beunan [7], has had a
527 reported variance of ± 0.592 yrs [28]. These findings suggest those individuals who are within this
528 acknowledged range could be wrongfully grouped, ultimately decreasing the clarity of results and
529 likely effecting the significance of findings. Future recommendations regarding this concept include
530 utilising a greater diversity of ages to provide a more distinct maturational difference between
531 groups. It is also suggested training studies aiming to improve sprint performance through
532 muscular and neural enhancements, should incorporate protective elements to allow the safe
533 dissipation of forces and eccentric control required to accommodate any power developments.
534 Future recommendations would also suggest the quantification of extra-curricular exercise,
535 physical education classes and sports trainings in order to help clarify the differences between
536 training adaptations, and those gained as a natural consequence of biological maturation.

537 **5. Conclusions**

538 A summary of the findings from the current study has revealed a variety of aspects worthy of
539 consideration when implementing intervention and coaching strategies across various levels of
540 maturation. The use of a progressive coaching style incorporating elements of problem solving,
541 competition, group interaction and guided feedback has shown to be more effective for individuals
542 within the pre-PHV growth-phase. This was inconsistent between maturation levels, as the circa-
543 PHV responded more effectively to the traditional coaching style that incorporated direct
544 individual feedback focussing on repetition and self-improvement, likely influenced by the impact
545 of adolescent awkwardness. Finally, the post-PHV group showed a less-effective response to the
546 training groups than they did to the natural benefits gained throughout natural biological
547 maturation in the control group. These findings suggest that varying levels of biological maturation
548 may require the use of unique coaching strategies in order to prompt the most effective outcomes
549 from training programmes being implemented. Final recommendations of this study include the
550 need for strengthening exercises to help decrease the risk of injury encountered within movements

551 requiring repetitive high force outputs. This could be pursued through resistance training or
 552 plyometric interventions, or possibly through movement-based coaching strategies. With the lack of
 553 significant differences between groups, accompanied with sprint and jump performance
 554 improvements throughout maturation levels and training groups, it is recommended that a variety
 555 of coaching methods be used to target individual learning styles if a movement-based sprint
 556 intervention is being implemented. It is also imperative to re-iterate that natural improvements in
 557 movement-based activities are likely during biological maturation, and coaches working with these
 558 athletes need to acknowledge these when quantifying the effectiveness of any training
 559 interventions.

560

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 562 analysis, R.S.; investigation, R.S., P.M; resources, R.S., P.M; data curation, R.S.; writing—original draft
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568 Appendix A

Phase of jump	Criterion	View	None (0)	Small (1)	Large (2)
Knee and thigh motion	1. Lower Extremity valgus at landing	F	No valgus	Slight Valgus	Obvious valgus: Both knees touch
	2. Thighs do not reach parallel (peak of jump)	L	The knees are higher or at the same level as the hips	The middle of the knees are at a lower level than the middle of the hips	The whole knees are under the entire hips
	3. Thighs not equal side to-side during flight	F	Thighs equal side to side	Thighs slightly unequal side to side	Thighs completely unequal side to side (one knee over the other)
Foot position during landing	4. Foot placement not shoulder width apart	F	Foot placement exactly shoulder width apart	Foot placement less than shoulder width but more than one foot width of one another	Foot placement less than one foot width of one another
	5. Foot placement not	L	Foot placement parallel (end of	Foot placement unparallel (end of feet	Foot placement obviously

	parallel (front to back)		feet within big toe length)	greater than big toe length, but less than half their foot)	unparalleled (end of feet greater than half their foot length)
	6. Foot contact timing not equal (Asymmetrical landing)	F	Foot contact timing equal side-to-side	Foot contact timing slightly unequal	Foot contact timing completely unequal
	7. Excessive landing contact noise	F / L	Subtle noise at landing (landing on balls of feet)	Audible noise at landing (heels touch ground during landing but controlled)	Loud and pronounced noise at landing (entire foot and heel touch ground during landing with lack of control)
	8. Pause between jumps	F / L	Reactive and reflex jumps	Small pause between jumps	Large pause between jumps or double contact between jumps
	9. Technique declines prior ten seconds	F / L	No decline in technique	Decline in technique after five secs	Decline in technique before five seconds
Plyometric ability	10. Does not land in same foot print (Consistent point of landing)	F / L	Touches tape with both feet	One foot on tape, one foot not touching tape	Both feet miss tape

Note: F = Frontal view; L = Lateral view

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575 Appendix B

Appendix B: Pre and post mean \pm SD kinematic measures for training and maturation groups

			Control			Traditional			Progressive											
			Pre	\pm	SD	Post	\pm	SD	Pre	\pm	SD	Post	\pm	SD						
SL S1	(m)	All	1.04	\pm	0.09	1.08	\pm	0.14	1.08	\pm	0.11	1.12	\pm	0.14†	1.06	\pm	0.11	1.07	\pm	0.11
		Pre	1.00	\pm	0.05	1.03	\pm	0.08							0.98	\pm	0.06	1.02	\pm	0.07
		Circa	1.04	\pm	0.10	1.04	\pm	0.17	1.11	\pm	0.05	1.20	\pm	0.20	0.96	\pm	0.11	0.99	\pm	0.12
		Post	1.07	\pm	0.07	1.15	\pm	0.08	1.09	\pm	0.10	1.12	\pm	0.08*	1.11	\pm	0.10	1.11	\pm	0.09
SL S2	(m)	All	1.15	\pm	0.19	1.20	\pm	0.11*	1.22	\pm	0.11	1.21	\pm	0.13	1.17	\pm	0.12	1.20	\pm	0.13
		Pre	1.14	\pm	0.09	1.14	\pm	0.07							1.07	\pm	0.08	1.12	\pm	0.15
		Circa	1.14	\pm	0.12	1.19	\pm	0.10*	1.21	\pm	0.12	1.17	\pm	0.10†	1.13	\pm	0.08	1.17	\pm	0.11
		Post	1.17	\pm	0.11	1.25	\pm	0.13*	1.24	\pm	0.10	1.24	\pm	0.12†	1.22	\pm	0.13	1.23	\pm	0.12†
SL S3	(m)	All	1.27	\pm	0.09	1.23	\pm	0.10	1.32	\pm	0.14	1.31	\pm	0.11	1.29	\pm	0.13	1.32	\pm	0.17
		Pre	1.27	\pm	0.05	1.24	\pm	0.05							1.22	\pm	0.11	1.29	\pm	0.09
		Circa	1.26	\pm	0.10	1.27	\pm	0.09	1.34	\pm	0.11	1.29	\pm	0.11	1.25	\pm	0.09	1.30	\pm	0.16
		Post	1.30	\pm	0.09	1.37	\pm	0.10*	1.34	\pm	0.13	1.34	\pm	0.10†	1.33	\pm	0.13	1.33	\pm	0.11†
SL S4	(m)	All	1.35	\pm	0.10	1.35	\pm	0.08	1.36	\pm	0.11	1.34	\pm	0.14	1.38	\pm	0.16	1.39	\pm	0.17
		Pre	1.30	\pm	0.10	1.27	\pm	0.06							1.25	\pm	0.10	1.35	\pm	0.09
		Circa	1.32	\pm	0.09	1.34	\pm	0.08							1.30	\pm	0.05	1.31	\pm	0.07
		Post	1.43	\pm	0.07	1.42	\pm	0.05	1.39	\pm	0.09	1.37	\pm	0.12	1.44	\pm	0.17	1.43	\pm	0.14
SL 15m	(m)	All	1.71	\pm	0.10	1.73	\pm	0.11	1.76	\pm	0.12	1.76	\pm	0.12	1.70	\pm	0.14	1.75	\pm	0.12*
		Pre	1.68	\pm	0.09	1.69	\pm	0.12							1.67	\pm	0.05	1.67	\pm	0.06
		Circa	1.67	\pm	0.08	1.70	\pm	0.08	1.75	\pm	0.08	1.76	\pm	0.12	1.68	\pm	0.03	1.77	\pm	0.03*
		Post	1.78	\pm	0.10	1.78	\pm	0.14	1.78	\pm	0.12	1.78	\pm	0.10	1.72	\pm	0.18	1.76	\pm	0.14
CT S1	(s)	All	0.22	\pm	0.02	0.22	\pm	0.03*	0.25	\pm	0.19	0.22	\pm	0.03	0.22	\pm	0.03	0.22	\pm	0.02
		Pre	0.21	\pm	0.04	0.21	\pm	0.04	0.22	\pm	0.01	0.22	\pm	0.03	0.22	\pm	0.04	0.22	\pm	0.03

		Circa	0.22 ± 0.03	0.22 ± 0.03	0.21 ± 0.03	0.22 ± 0.03	0.21 ± 0.02	0.21 ± 0.02
		Post	0.22 ± 0.01	0.23 ± 0.02*	0.28 ± 0.24	0.22 ± 0.03	0.23 ± 0.03	0.23 ± 0.02†
CT S2	(s)	All	0.22 ± 0.10	0.20 ± 0.02	0.20 ± 0.02	0.20 ± 0.02	0.20 ± 0.02	0.20 ± 0.02
		Pre	0.20 ± 0.02	0.21 ± 0.03	0.20 ± 0.02	0.20 ± 0.01	0.20 ± 0.02	0.19 ± 0.02
		Circa	0.24 ± 0.13	0.20 ± 0.02	0.20 ± 0.03	0.19 ± 0.01*‡	0.19 ± 0.02	0.19 ± 0.02
		Post	0.20 ± 0.02	0.19 ± 0.01	0.19 ± 0.01	0.20 ± 0.02	0.20 ± 0.02	0.21 ± 0.02
CT S3	(s)	All	0.19 ± 0.02	0.19 ± 0.02	0.18 ± 0.02	0.18 ± 0.02	0.19 ± 0.02	0.18 ± 0.02
		Pre	0.18 ± 0.02	0.18 ± 0.03	0.19 ± 0.02	0.19 ± 0.01	0.19 ± 0.03	0.18 ± 0.02
		Circa	0.19 ± 0.02	0.19 ± 0.02	0.18 ± 0.02	0.18 ± 0.01	0.18 ± 0.02	0.18 ± 0.01
		Post	0.19 ± 0.01	0.19 ± 0.01	0.18 ± 0.01	0.18 ± 0.02	0.19 ± 0.02	0.19 ± 0.02
CT S4	(s)	All	0.17 ± 0.02	0.17 ± 0.02	0.17 ± 0.02	0.17 ± 0.01	0.18 ± 0.02	0.17 ± 0.02
		Pre	0.16 ± 0.03	0.17 ± 0.02	0.17 ± 0.02	0.17 ± 0.01	0.18 ± 0.03	0.16 ± 0.01
		Circa	0.18 ± 0.02	0.17 ± 0.02	0.18 ± 0.02	0.16 ± 0.02*	0.17 ± 0.02	0.17 ± 0.02
		Post	0.17 ± 0.02	0.17 ± 0.01	0.17 ± 0.02	0.17 ± 0.01	0.18 ± 0.02	0.18 ± 0.02
CT 15m	(s)	All	0.18 ± 0.10	0.15 ± 0.02	0.16 ± 0.02	0.15 ± 0.01*‡	0.16 ± 0.02	0.15 ± 0.02
		Pre	0.15 ± 0.02	0.15 ± 0.02	0.17 ± 0.02	0.15 ± 0.01	0.16 ± 0.03	0.15 ± 0.02
		Circa	0.20 ± 0.13	0.15 ± 0.02	0.16 ± 0.02	0.14 ± 0.02*‡	0.15 ± 0.02	0.15 ± 0.01
		Post	0.15 ± 0.01	0.15 ± 0.02	0.15 ± 0.02	0.15 ± 0.01	0.16 ± 0.02	0.16 ± 0.02
FT S1	(s)	All	0.05 ± 0.02	0.05 ± 0.01	0.05 ± 0.02	0.05 ± 0.02	0.05 ± 0.01	0.05 ± 0.01
		Pre	0.04 ± 0.02	0.05 ± 0.02	0.04 ± 0.01	0.04 ± 0.02	0.05 ± 0.01	0.05 ± 0.01
		Circa	0.05 ± 0.01	0.05 ± 0.01	0.05 ± 0.02	0.06 ± 0.02*†	0.05 ± 0.01	0.05 ± 0.02
		Post	0.05 ± 0.02	0.05 ± 0.01	0.05 ± 0.02	0.05 ± 0.01	0.04 ± 0.02	0.04 ± 0.01
FT S2	(s)	All	0.06 ± 0.02	0.06 ± 0.01	0.06 ± 0.02	0.06 ± 0.02	0.06 ± 0.01	0.06 ± 0.02
		Pre	0.06 ± 0.00	0.05 ± 0.01	0.05 ± 0.01	0.05 ± 0.02	0.05 ± 0.00	0.06 ± 0.01
		Circa	0.06 ± 0.02	0.06 ± 0.02	0.06 ± 0.01	0.06 ± 0.02	0.05 ± 0.01	0.05 ± 0.02
		Post	0.06 ± 0.01	0.06 ± 0.01	0.06 ± 0.02	0.06 ± 0.02	0.06 ± 0.02	0.06 ± 0.02
FT S3	(s)	All	0.07 ± 0.01	0.07 ± 0.01	0.07 ± 0.02	0.08 ± 0.08	0.07 ± 0.01	0.07 ± 0.01

	Pre	0.07 ± 0.01	0.07 ± 0.01	0.07 ± 0.01	0.15 ± 0.22	0.07 ± 0.01	0.08 ± 0.02
	Circa	0.07 ± 0.01	0.07 ± 0.01	0.07 ± 0.01	0.07 ± 0.02	0.07 ± 0.01	0.07 ± 0.01
	Post	0.07 ± 0.02	0.07 ± 0.01*	0.07 ± 0.02	0.07 ± 0.01	0.07 ± 0.02	0.07 ± 0.01
FT 15m (s)	All	0.09 ± 0.01	0.10 ± 0.01	0.09 ± 0.02	0.10 ± 0.02*	0.09 ± 0.02	0.10 ± 0.01*
	Pre	0.10 ± 0.02	0.11 ± 0.01	0.09 ± 0.01	0.10 ± 0.02	0.10 ± 0.02	0.10 ± 0.01
	Circa	0.09 ± 0.01	0.09 ± 0.01	0.09 ± 0.02	0.10 ± 0.01*	0.09 ± 0.02	0.10 ± 0.01*†
	Post	0.09 ± 0.01	0.10 ± 0.02	0.10 ± 0.01	0.10 ± 0.02	0.09 ± 0.02	0.10 ± 0.01
SF S1 (Hz)	All	3.82 ± 0.40	3.73 ± 0.37	3.74 ± 0.51	3.82 ± 0.44 [†]	3.86 ± 0.45	3.80 ± 0.32
	Pre	3.94 ± 0.47	3.91 ± 0.35	3.92 ± 0.36	3.90 ± 0.71	3.84 ± 0.56	3.73 ± 0.32
	Circa	3.81 ± 0.44	3.77 ± 0.35	3.90 ± 0.45	3.70 ± 0.40	4.03 ± 0.40	3.92 ± 0.38
	Post	3.80 ± 0.34	3.57 ± 0.38	3.63 ± 0.55	3.85 ± 0.40 [†]	3.77 ± 0.45	3.75 ± 0.28
SF S2 (Hz)	All	3.80 ± 0.48	3.92 ± 0.34	3.90 ± 0.31	3.88 ± 0.46	3.96 ± 0.34	3.90 ± 0.33
	Pre	3.91 ± 0.34	3.91 ± 0.29	4.00 ± 0.17	3.60 ± 0.93	3.99 ± 0.36	4.06 ± 0.35
	Circa	3.68 ± 0.57	3.88 ± 0.37	3.80 ± 0.34	4.01 ± 0.36 [‡]	4.18 ± 0.35	4.02 ± 0.33 [†]
	Post	3.98 ± 0.25	4.00 ± 0.35	3.91 ± 0.32	3.89 ± 0.34	3.84 ± 0.28	3.80 ± 0.32
SF S3 (Hz)	All	3.91 ± 0.26	3.98 ± 0.40	3.96 ± 0.35	3.98 ± 0.32	3.99 ± 0.33	3.99 ± 0.37
	Pre	4.10 ± 0.08	4.36 ± 0.85	3.96 ± 0.55	3.91 ± 0.45	3.92 ± 0.41	3.89 ± 0.58
	Circa	3.89 ± 0.25	3.93 ± 0.34	3.94 ± 0.35	3.92 ± 0.27	4.10 ± 0.31	4.10 ± 0.38
	Post	3.89 ± 0.31	3.91 ± 0.22	3.97 ± 0.33	4.01 ± 0.32	3.96 ± 0.33	3.97 ± 0.32
Sf 15m (Hz)	All	3.93 ± 0.43	4.05 ± 0.33	4.05 ± 0.36	4.10 ± 0.38	4.10 ± 0.40	4.24 ± 0.90
	Pre	3.96 ± 0.23	4.01 ± 0.30	3.85 ± 0.32	4.01 ± 0.32	3.90 ± 0.44	4.06 ± 0.16
	Circa	3.84 ± 0.52	4.06 ± 0.31	4.13 ± 0.43	4.13 ± 0.38	4.18 ± 0.48	4.01 ± 0.30 [†]
	Post	4.08 ± 0.26	4.04 ± 0.43	4.06 ± 0.34	4.11 ± 0.42	4.10 ± 0.33	4.43 ± 1.19

Note: * = significant difference ($p < 0.05$) pre vs post; † = significant difference ($p < 0.05$) to control change scores, ‡ = significant difference ($p < 0.05$) to traditional change scores.

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