



## 37 **1 Introduction**

38 Soccer is the most popular team sports globally [1]–[4]. According to a wide-scale  
39 survey by Fédération Internationale de Football Association (FIFA) in 2006, approxi-  
40 mately 270 million people or 4% of the world’s population were actively involved in  
41 soccer worldwide. Surprisingly, the growth in total of youth soccer participation in-  
42 crease to 7 % compared to the first survey conducted in the year 2000 [5]. Nevertheless,  
43 little research attention has been devoted to the youth soccer compared to the adult  
44 players. Overall, the popularity of soccer has led to teams and players embracing sci-  
45 entific applications for training and preparation mostly for adults players. Conse-  
46 quently, a significant body of research has developed which is evident in the numbers  
47 of research findings published across a variety of disciplines, namely physiology [6],  
48 performance analysis [7], [8], nutrition and performance [9], [10] and injury related to  
49 soccer [11]–[13]. As technology has advanced, monitoring players during match play  
50 has become a fundamental approach to gain understanding on soccer demands [14]–  
51 [17]. Typically, the physical demands of soccer are measured by the total distance cov-  
52 ered by the players. The examination of the activity pattern and physical aspects of  
53 soccer play enables coaches to identify the strengths and weaknesses of the players  
54 under their care. In turn, this information and data may help them to prioritise areas for  
55 improvement among their players. Moreover, researchers have used these data to de-  
56 velop specific performance tests that simulate physiological responses as close as pos-  
57 sible to actual soccer match-play [18], [19].

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59 In the last decade, the Soccer Simulation Protocol (SSP) has been used as a more  
60 comprehensive approach to investigate soccer specific performances [2], [20]–[22].  
61 The protocols attempt to replicate the exercise patterns and physiological responses  
62 similar to that occur in match play such as; the total distance covered, duration, match  
63 activity patterns and time spent in each match activity pattern [2]. These running activ-  
64 ities are repeated in cyclical patterns with the speed of each pattern being dictated by  
65 an audible signal [23], [24]. The development of these protocols arose from a need to  
66 derive clear benefit from manipulating various variables in soccer performance in a  
67 controlled scientific environment [25]. The inherent variability in soccer from match to  
68 match makes it difficult to draw meaningful inferences from interventions conducted.  
69 The physical and physiological demands can vary between games because of environ-  
70 mental conditions, the strengths of the opposition and the fitness of players [17], [26].  
71 Therefore, to understand the demands of soccer in a manner similar to match play, there  
72 is a need to investigate players using the SSP as a more practical method that allows  
73 control for research purposes.

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75 To date, most of these protocols have been developed for adults and there are limited  
76 protocols reported useful for young athletes [23], [27], [28]. Far less attention has been  
77 paid to develop age appropriate SSP for young soccer players as the playing durations  
78 and the total distance covered are dependent on their age groups and less than that of  
79 adult games [3]. Moreover, young players have different physiological attributes during

80 prolonged intermittent exercise including different substrate utilization, less well de-  
81 veloped thermoregulatory responses, inferior aerobic and anaerobic capacity and lower  
82 glycogen stores [3]. There have been previous attempts to develop protocols suitable  
83 for young athletes but these attempts have been hindered by various methodological  
84 limitations [24], [29], [30]. No study has yet effectively simulated a SSP that focuses  
85 on young players that included intermittent running with repeated sprint ability based  
86 on actual match analysis data, undertaken formal reliability and validity testing or and  
87 integrated match-play movements like backward and sideways running in young play-  
88 ers.

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90 Considering that today, potential young athletes with talent have start training and  
91 specialize at an early stage [31]–[33], there is an unmet need for a suitable protocol to  
92 help in the foundational development of these young talents. The development of a  
93 soccer running protocol for young players ( $\leq$  U15) is necessary, as there are many con-  
94 cerns that surround the training and participation of young athletes in competitive soc-  
95 cer. Guidelines for youth sports have been established with very little scientific evi-  
96 dence and still contain vague descriptions concerning the age of participants, hours and  
97 structure of practice [34]. A SSP suited to younger age groups can be used in many  
98 ways, among which are investigating training/ ergogenic interventions and monitoring  
99 athletic progress as in adult studies. Results from this investigation would be able to  
100 develop suitable guidelines for youth soccer to train and compete in a safe yet effective  
101 manner.

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103 The key factors for a good performance test are its validity and reliability. A valid  
104 test protocol replicates the soccer match as close as possible (Da Silva et al., 2011).  
105 Validity in the SSP protocol refers to the simulation of similar movement patterns, total  
106 distance covered, the duration of playing and recovery intervals as well as the physio-  
107 logical responses found in match play (Currell & Jeukendrup, 2008). Whereas, reliabil-  
108 ity refers to the protocol’s consistency or reproducibility when it is performed repeat-  
109 edly [35]. Given the limitations associated with assessing young players from different  
110 age groups, we have devised novel shuttle-running simulations for youth players based  
111 on match analysis data from three age groups (U13, U14 and U15). These protocols  
112 were designed to simulate the total distance covered, duration of playing, physiological  
113 demands and match activity patterns observed during match-play. Therefore, this study  
114 aims to assess the reliability and validity of these new simulation protocols adaptations  
115 for use with young soccer players aged 12-15 years old. It is hypothesized that there is  
116 no differences between trials and the SSPs is a valid representation of the youth soccer  
117 match-play.

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## 121 **2 Methodology**

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### 2.1 Match Analysis

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Prior to the development of the SSPs, match analysis data were collected on 85 outfield players competing within the Auckland Football Federation (AFF) Metropolitan League who volunteered to participate in the study. The participants were categorized into 3 age groups, based on their age as of January 1st in the calendar year, classed as under 13 years (U13;  $n = 28$ ,  $1.54 \pm 0.8$  m, and  $43.9 \pm 7.1$  kg), under 14 years (U14;  $n = 27$ ,  $1.66 \pm 0.4$  m, and  $56.5 \pm 8.6$  kg), and under 15 years (U15;  $n = 30$ ,  $1.67 \pm 0.8$  m, and  $58.1 \pm 9.5$  kg). The match analysis data provide useful information for developing framework for developing age-specific soccer simulation protocols (see Table 1).

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All games were played in agreement with the rules outlined by the FIFA. All age groups played 11-a-side games, on a full-sized pitch (60 x 100 m), with a “rolling substitute policy.” Match configuration varied between age groups, with U13 playing 2 x 30-minute periods, U14 playing 2 x 35-minute periods, whereas the U15 played 2 x 40-minute periods New Zealand Football rules in line with FIFA recommendations. For each age group, teams were allowed to use up to 3 substitutes (from 5 named substitutes) with unlimited interchange of players at any time during the match.

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### 2.2 Participants

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For validation of the SSPs, players were recruited from the representative teams from the Auckland Football Federation (AFF), Auckland, New Zealand. Twenty ( $n = 20$ ) young male outfield soccer players volunteered to participate in the study. The participants were categorised into three age-groups: under 13 y (U13;  $n = 7$ ,  $1.57 \pm 0.06$  m,  $47.8 \pm 6.8$  kg), under 14 y (U14;  $n = 7$ ,  $1.70 \pm 0.06$  m,  $60.4 \pm 8.4$  kg) and under 15 y (U15;  $n = 6$ ,  $1.75 \pm 0.07$  m,  $58.1 \pm 2.6$  kg). All participants provided assent to participate and their parents gave their written informed consent, and the study was approved by the local institutional ethics committee.

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### 2.3 Familiarisation

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All participants attended one preliminary session to familiarise themselves with the protocol procedures along with height and body mass (BM) measurements. The participants were fully familiarised with the countermovement jump (CMJ) and perceptual scales; ratings of perceived exertion (RPE) [36], feeling scale (FS) [37] and felt arousal scale (FAS) [38].

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### 2.4 Experimental Design

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Following familiarisation, the SSPs were performed in full on two occasions (separated by 7 days). Participants were asked to refrain from strenuous physical activity 24 h before each trial, record dietary intake (24 h before the first protocol) and required to

166 replicate the same diet prior to trial 2. Both trials took place on an outdoor artificial  
 167 grass field in temperate conditions (18-22°C, 40-60% relative humidity; ETHG-912;  
 168 Oregon Scientific, USA). There were no differences in temperature or humidity be-  
 169 tween trials.

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171 On arrival, participants emptied their bladder and a small sample of urine was used  
 172 to measure hydration status via a handheld refractometer (Sur-Ne, Atago Co. Ltd, Ja-  
 173 pan). Body Mass (BM) was recorded using electronic weighing scales (HV200KGL  
 174 NTEP, Industrial Balance, USA). After donning the 5 Hz Global Positioning Unit  
 175 (GPS) unit (with interpolated 10 Hz output) and heart rate strap (GPSports Systems,  
 176 Australia), participants performed 10 min of a standardised warm-up, consisting of jog-  
 177 ging, striding and dynamic stretching. Participants consumed 5 mL·kg<sup>-1</sup> BM of water  
 178 before commencing the main trial from individual, clearly labelled, sipper bottles.

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180 The SSP was set up accordingly for each age group; U13 performed 4 x 15-min  
 181 'blocks' of exercise (SSP-13) separated by 3 min recovery, U14 performed 4 x 17.5-  
 182 min of exercise (SSP-14) separated by 5 min recovery and U15 performed 4 x 20-min  
 183 of exercise (SSP-15) separated by 5 min recovery (see Figure 1). The multiple breaks  
 184 also represented the 15 min rest duration during the half time interval in a soccer match.  
 185 The FS and FAS scales were administered prior to exercise. Within the rest periods  
 186 between exercise blocks, RPE, FS and FAS (in that order) and CMJ were administered  
 187 and participants ingested the equivalent of 2 mL·kg<sup>-1</sup> BM of water (see Figure 1). Heart  
 188 rate (HR) was monitored continuously at 5-s intervals (GPSports Systems, Australia)  
 189 and BM was again obtained on completion of the protocol.

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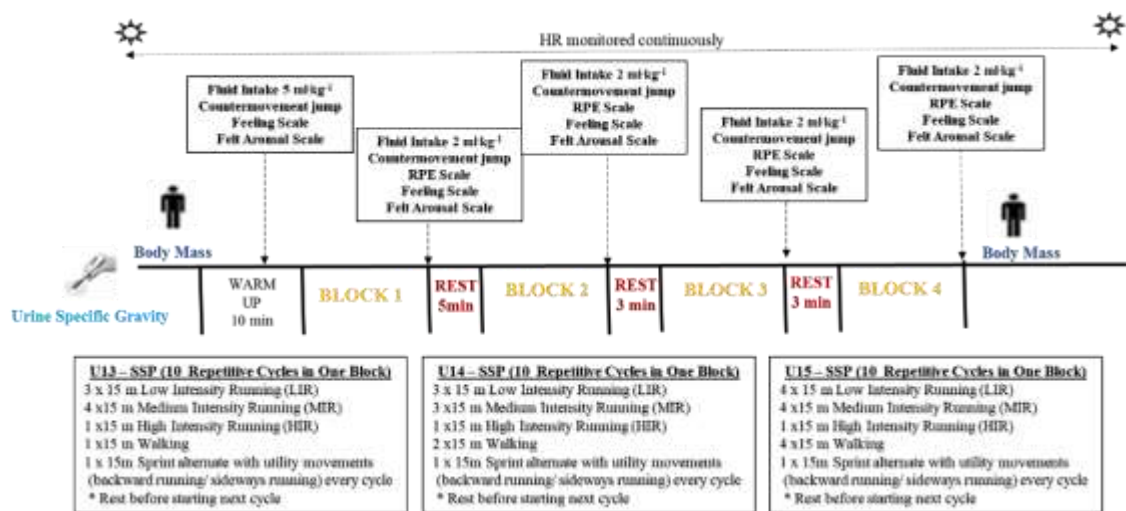
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Fig. 1. Schematic Representation of the SSPs for each age group.

200 **2.5 SSP-13, SSP-14 and SSP-15 Protocols**

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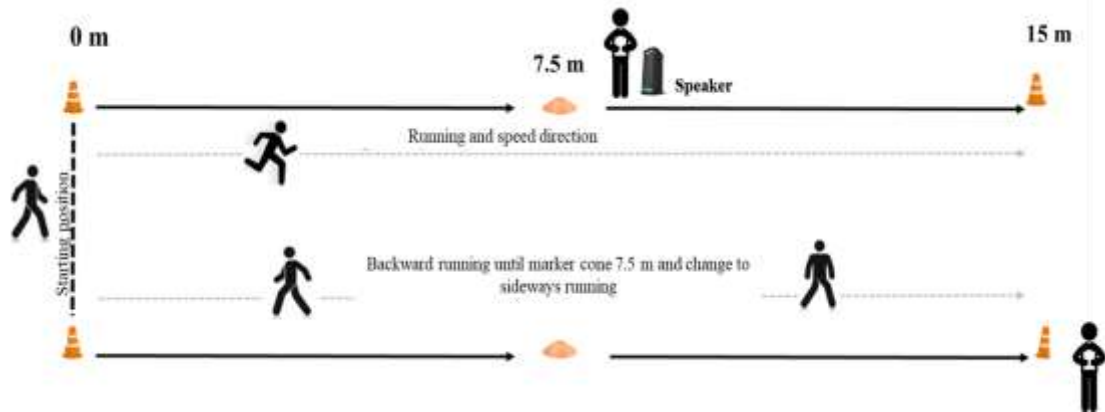
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These protocols were designed to replicate the activity pattern typically recorded in youth soccer. The activities during the SSP were based on match analysis data i.e. replicating total distance (m) and time spent in each match activity for each age group (Table 1). Due to a ‘rolling’ substitution policy, the total distances in each match were calculated in relative terms which is distance covered per playing minute ( $\text{m}\cdot\text{min}^{-1}$ ) to accurately represent the typical distances covered in each age group. The SSP were designed in cyclical patterns and the speed of each match activity was defined accordingly to the match speed thresholds (middle range) for each age group (Table 2).

All SSPs consist of four blocks of exercise that simulates match-playing time according to age-groups. These protocols require participants to run between two lines (15 m apart) at various speeds (Figure 2). The exercises include low and high intensity activities such as walking, low intensity running, medium intensity running, and high intensity running, sprinting as well as utility movements (Table 2). At every cycle, participants were required to alternate between sprinting and utility (backward running at the first 7.5 m followed by sideways running). Speeds for each activity were dictated via an audible signal (and voice) from software specifically developed for these tests. Marker cones were placed at 7.5 m to indicate when participants should change utility movements (Figure 1). Sprint speed ( $\text{km}\cdot\text{h}^{-1}$ ) was measured in one direction using 5 Hz GPS unit (GPSports Systems, Australia). For other performance measure, the participants performed CMJ pre, during and post-exercise (see Figure 2).



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**Fig. 2.** Running direction for the SSP

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**Table 1.** The total distance covered, percentage of distance and time spent in each movement in actual match-play (match) and the soccer simulation protocol

Activity	Distance		% of distance in each match activity		% of time spent in each match activity	
	Match (m·min <sup>-1</sup> )	Protocol (m)	Match	Protocol	Match	Protocol
SSP-U13 (60 min protocol)						
Total distance	5700	6000				
Standing	-	-	-	-	15	16%
Walking	700	600	12	10%	25%	20%
Low Intensity Running	1800	1800	32%	30%	32%	30%
Medium Intensity Running	2000	2400	35%	40%	19%	24%
High Intensity Running	900	600	16%	10%	6%	4.4%
Sprinting	300	300	5%	5%	1.4%	1.7%
Utility movement		300		5%	* 4 %	3.3%
SSP-U14 (70 min protocol)						
Total distance	6700	6600				
Standing	-	-	-	-	14%	15%
Walking	1100	1320	16%	20%	29%	36%
Low Intensity Running	2000	1980	30%	30%	31%	25%
Medium Intensity Running	2300	1980	34%	30%	19%	16%
High Intensity Running	900	660	14%	10%	5%	4.2%
Sprinting	400	360	6%	5.5%	2%	1.4%
Utility movement		300		4.5%	* 4%	3.4%
SSP-U15 (80 min protocol)						
Total distance	7600	7800				
Standing	-	-	-	-	14%	15%
Walking	1800	1560	24%	20%	39%	34%
Low Intensity Running	2400	2340	31%	30%	27%	28%
Medium Intensity Running	2500	2340	33%	30%	16%	15%
High Intensity Running	600	780	8%	10%	3%	3.8%
Sprinting	300	360	4%	4.6%	1%	1.5%
Utility movement		420		5.4%	* 4%	3.5%

\* Utility movement was adapted from Capranica et al. (2010) which is 4% of time spent in a soccer match

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Table 2. The order and running speeds for SSP-13, SSP-14 and SSP-15

Exercise duration	U13 (60 min protocol)		U14 (70 min protocol)		U15 (80 min protocol)	
	Blocks	Cycle	Blocks	Cycle	Blocks	Cycle
	4 x 15 min	10 cycles	4 x 17.5 min	10 cycles	4 x 20 min	10 cycles
Low intensity running	Order 3 x 15 m	Speed 1.66 m·s <sup>-1</sup>	Order 3 x 15 m	Speed 1.88 m·s <sup>-1</sup>	Order 4 x 15 m	Speed 1.77 m·s <sup>-1</sup>
Medium intensity running	4 x 15 m	2.72 m·s <sup>-1</sup>	3 x 15 m	3.00 m·s <sup>-1</sup>	4 x 15 m	3.33 m·s <sup>-1</sup>
High intensity running	1 x 15 m	3.75 m·s <sup>-1</sup>	1 x 15 m	3.75 m·s <sup>-1</sup>	1 x 15 m	4.27 m·s <sup>-1</sup>
Walking	1 x 15 m	0.83 m·s <sup>-1</sup>	2 x 15 m	0.88 m·s <sup>-1</sup>	4 x 15 m	0.97 m·s <sup>-1</sup>
Sprinting alternate with utility movements (backward running / sideways running)	1 x 15 m	Maximal intensity/ 2.72 m·s <sup>-1</sup>	1 x 15 m	Maximal intensity/ 3.00 m·s <sup>-1</sup>	1 x 15 m	Maximal intensity/ 3.00 m·s <sup>-1</sup>

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### 231 3 Statistical Analysis

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All results are reported as means  $\pm$  standard deviations. Paired sample t-test was used to determine whether there were any differences in physiological and physical measures between trials for each age group. Pearson's correlation ( $r$ ) and intra-class correlation coefficients (ICC) were used to determine the repeatability between trials set of scores. In the ICC, the "two-way random" method was used as suggested by Atkinson & Nevill, (1998). The standard error of measurement (SEM) with 95% confidence intervals (95% CI) was further used to assess the reliability. The common method to calculate is  $SEM = SD (\sqrt{1-ICC})$  however this only applicable to 68% of population. To make it applicable for 95% of population this formula was used:  $95\% CI = 1.96 \times SEM$  [39]. Pearson product moment correlation ( $r$ ) was also used to assess the concurrent validity of the SSPs. All statistical analyses were performed with SPSS software (version 21.0, SPSS inc, Chicago, IL) with the level of significance set at  $p \leq 0.05$ .

### 248 4 Results

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A summary of the physiological and physical measurements for both trials in the SSP-13, SSP-14 and SSP-15 is in Table 3. Summary of result for  $r$ , ICC, 95 % of CI are presented in Table 4.

#### 255 4.1 Physiological Measurements

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There were no differences between trials in BM loss (kg loss) ( $p=0.848$ ,  $p=0.622$ ,  $p=0.869$ ) and similar hydrated state on both trials ( $p= 0.666$ ,  $p=0.967$ ,  $p=0.344$ ) in these protocols (SSP-13, SSP-14 and SSP-15) respectively. The SEM was low in these variables indicating the repeatability of these protocols (Table 4)

The HR data showed similar trends in all age groups. The HR increased towards the end of exercise as expected. There were no differences between trials (U13:  $p=0.781$ , U14: 0.433, U15:  $p=0.372$ ) (Figure 3). High correlations were observed in U13 ( $r=0.86$ ,  $p=0.012$ ) and U14 ( $r=0.81$ ,  $p=0.024$ ), however, moderate correlation in U15 although not significant ( $r=0.48$ ,  $p=0.341$ ). The ICC show similar result as  $r$  (Table 4) with LOA in U13: 2.4 to 2.6 beats $\cdot$ min $^{-1}$ , U14: 7.8 to 5.6 beats $\cdot$ min $^{-1}$  and U13: 5.0 to 7.6 beats $\cdot$ min $^{-1}$ .

Table 3. Performance and physiological measures in the soccer simulation protocol for three age groups (mean  $\pm$  SD)

Measure	SSP-13 n=7		SSP-14 n=7		SSP-15 n=6	
	Trial 1	Trial 2	Trial 1	Trial 2	Trial 1	Trial 2
Body mass loss (kg)	-0.06 $\pm$ 0.5	-0.08 $\pm$ 0.3	0.34 $\pm$ 0.5	0.47 $\pm$ 0.7	0.33 $\pm$ 0.4	0.36 $\pm$ 0.2
USG	1.017 $\pm$ 0.01	1.015 $\pm$ 0.01	1.017 $\pm$ 0.01	1.016 $\pm$ 0.01	1.015 $\pm$ 0.01	1.019 $\pm$ 0.01
RPE	11.7 $\pm$ 1.7	10.7 $\pm$ 1.3	11.3 $\pm$ 1.2	10.9 $\pm$ 2.0	13.1 $\pm$ 0.7	12.5 $\pm$ 0.5
FS	3.2 $\pm$ 1.5	3.1 $\pm$ 1.6	3.2 $\pm$ 1.3	2.8 $\pm$ 1.9	1.0 $\pm$ 1.1	1.3 $\pm$ 1.1
FAS	3.1 $\pm$ 0.6	3.5 $\pm$ 0.8	4.3 $\pm$ 1.0	4.2 $\pm$ 1.1	2.0 $\pm$ 0.6	2.5 $\pm$ 1.3
CMJ (cm)	16.5 $\pm$ 1.9	16.4 $\pm$ 1.8	17.1 $\pm$ 1.7	17.0 $\pm$ 1.5	19.1 $\pm$ 1.4	18.9 $\pm$ 1.2
Peak sprint speed (km h <sup>-1</sup> )	21.5 $\pm$ 2.9	21.6 $\pm$ 2.5	23.7 $\pm$ 1.2	22.9 $\pm$ 1.0	21.8 $\pm$ 0.8*	22.2 $\pm$ 0.9*
Heart rate (beats min <sup>-1</sup> )	187.9 $\pm$ 1.8	188.1 $\pm$ 2.5	182.8 $\pm$ 2.3	181.7 $\pm$ 5.1	193.1 $\pm$ 3.6	194.4 $\pm$ 1.3

USG= Urine specific gravity

SSP-13= Soccer simulation protocol for under 13; SSP-14=Soccer simulation protocol for under 14; SSP-15=Soccer simulation protocol for under 15

RPE=Rating of perceived exertion; FAS= Felt arousal scale; FS: Feeling scale

CMJ=Counter movement jump

\* significant difference between trials  $p < 0.05$

Table 4. Pearson' correlation (r), intra-class correlation coefficients (ICC), standard error of measurement (SEM) and 95% confidence intervals (95% CI) in SSP for three age groups

Variable	SSP-13			SSP-14			SSP-15			
	r	ICC	SEM	r	ICC	SEM	r	ICC	SEM	95% CI
RPE	0.76*	0.84	$\pm$ 0.2	0.85*	0.86	$\pm$ 0.2	0.24	0.38	$\pm$ 0.3	$\pm$ 0.6
FS	0.99**	0.99	$\pm$ 0.01	0.25	0.38	$\pm$ 0.8	0.82*	0.89	$\pm$ 0.1	$\pm$ 0.2
FAS	0.50	0.67	$\pm$ 0.2	0.65	0.78	$\pm$ 0.2	0.52**	0.82	$\pm$ 0.2	$\pm$ 0.3
CMJ	0.94**	0.97	$\pm$ 0.1	0.96**	0.98	$\pm$ 0.02	0.98**	0.98	$\pm$ 0.02	$\pm$ 0.04
Peak sprint speed	0.96*	0.98		0.95	0.96		0.98*	0.98		
Heart rate	0.87*	0.77	$\pm$ 0.1	0.82*	0.76	$\pm$ 0.8	0.48	0.47	$\pm$ 0.1	$\pm$ 0.2

SSP-13= Soccer simulation protocol for under 13; SSP-14=Soccer simulation protocol for under 14; SSP-15=Soccer simulation protocol for under 15

r= Pearson' product-moment correlation; ICC= Intra-class correlation; SEM= Standard error of measurement; 95% CI= 95% confidence interval; CI= coefficient of variation

RPE=Rating of perceived exertion; FAS= Felt arousal scale; FS: Feeling scale

CMJ=Counter movement jump

\* significant difference between trials  $p < 0.05$

## 272 4.2 Physical Measurements

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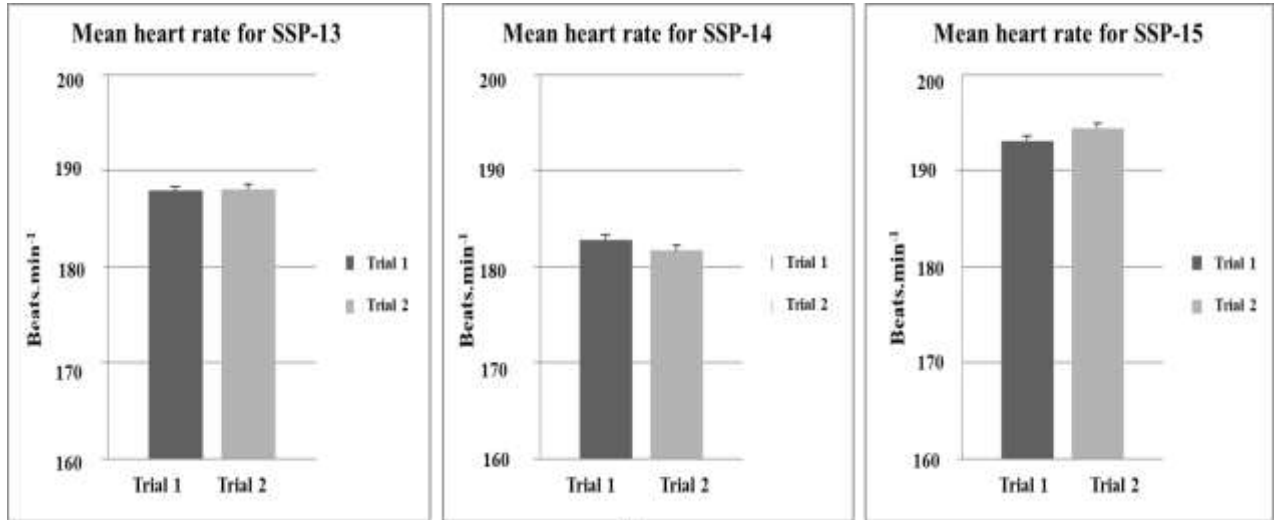
There were no differences in CMJ and peak sprint speed (Figure 4) was observed between trials in SSP-13 ( $p=0.829$ ,  $p=0.854$ ) and SSP-14 ( $p=0.656$ ,  $p=0.088$ ). A significant high correlation (Table 4) was also observed in SSP-13 for CMJ and peak sprint speed ( $p=0.036$ ). Meanwhile in SSP-14, a significant high correlation was noted in CMJ ( $p=0.001$ ) but not in the peak sprint speed ( $p=0.207$ ). Similar trend was observed in SSP-15, a significant high correlation was observed in both  $r$  and ICC for both CMJ ( $p=0.001$ ,  $p=0.015$ ) and peak sprint speed ( $p=0.001$ ,  $p=0.003$ ) respectively. The SEM in CMJ and peak sprint speed were reported lower and results in 95% CI (Table 4) providing the repeatability of these protocols.

## 4.3 Perceptual Scales

As expected, both trials showed the RPE increased in a linear fashion towards the end of SSPs (Figure 5), meanwhile the FS dropped towards the end of the protocols. Meanwhile, the trend in the FAS was undulated. Even so, all the perceptual scales (RPE, FS and FAS) followed a similar pattern of response during both trials with no significant differences between trials in all SSP's (Table 3 and 4). These provide evidence the repeatability of these protocols.

## 4.4 Validity of the Soccer Simulation Protocol

The results show that the match activities found in the U13, U14 and U15 actual match play and the SSPs were strongly correlated ( $r= 0.80, 0.84$  and  $0.85$ ) respectively. To provide more evidence of the face validity of the SSPs, comparison between match activities was made and are shown in Table 1. It is clear that similar trends can be seen in both match play and SSPs. The largest proportion or about 60 % of the time was spent in low intensity activities ranging from walking and LIR. This was followed by MIR and about 1-3% was spent in high intensity activities. The SSPs attempts to replicate as close as possible what has been reported to occur in U13, U14 and U15 match play. A paired sample t-test was also conducted to investigate the physiological responses during match play and in the SSPs. There was a statistically significant difference ( $p< 0.05$ ) in the HR scores in match play compared to the SSPs. The lower HR in the SSPs is most likely due to the lack of actual ball involvements and attacking or defending movements done in match play.



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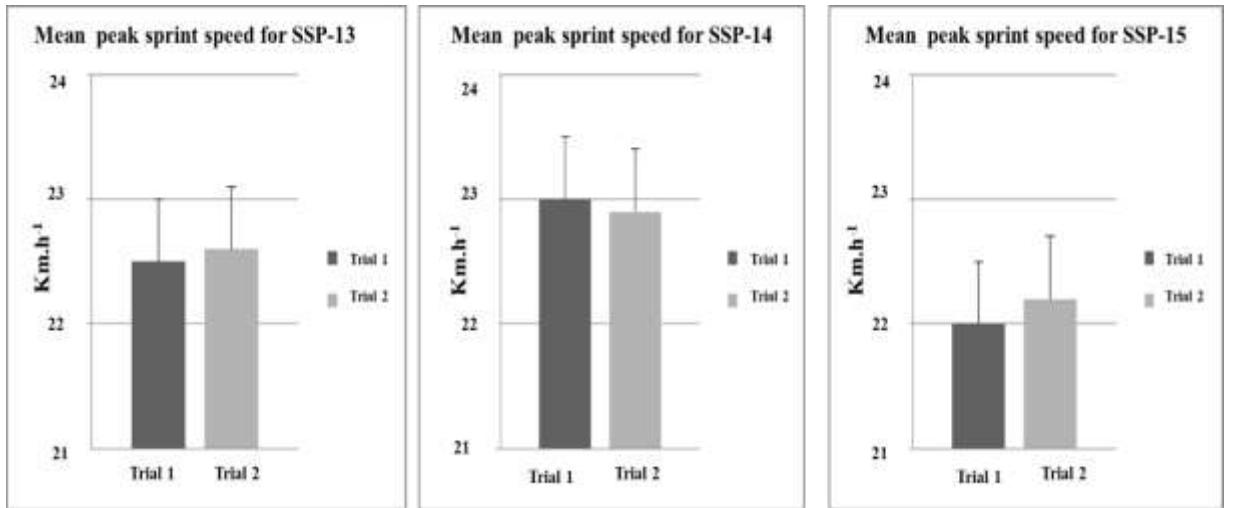
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Fig. 3. Mean heart rate (beats.min<sup>-1</sup>) in SSP-13, SSP-14 and SSP-15

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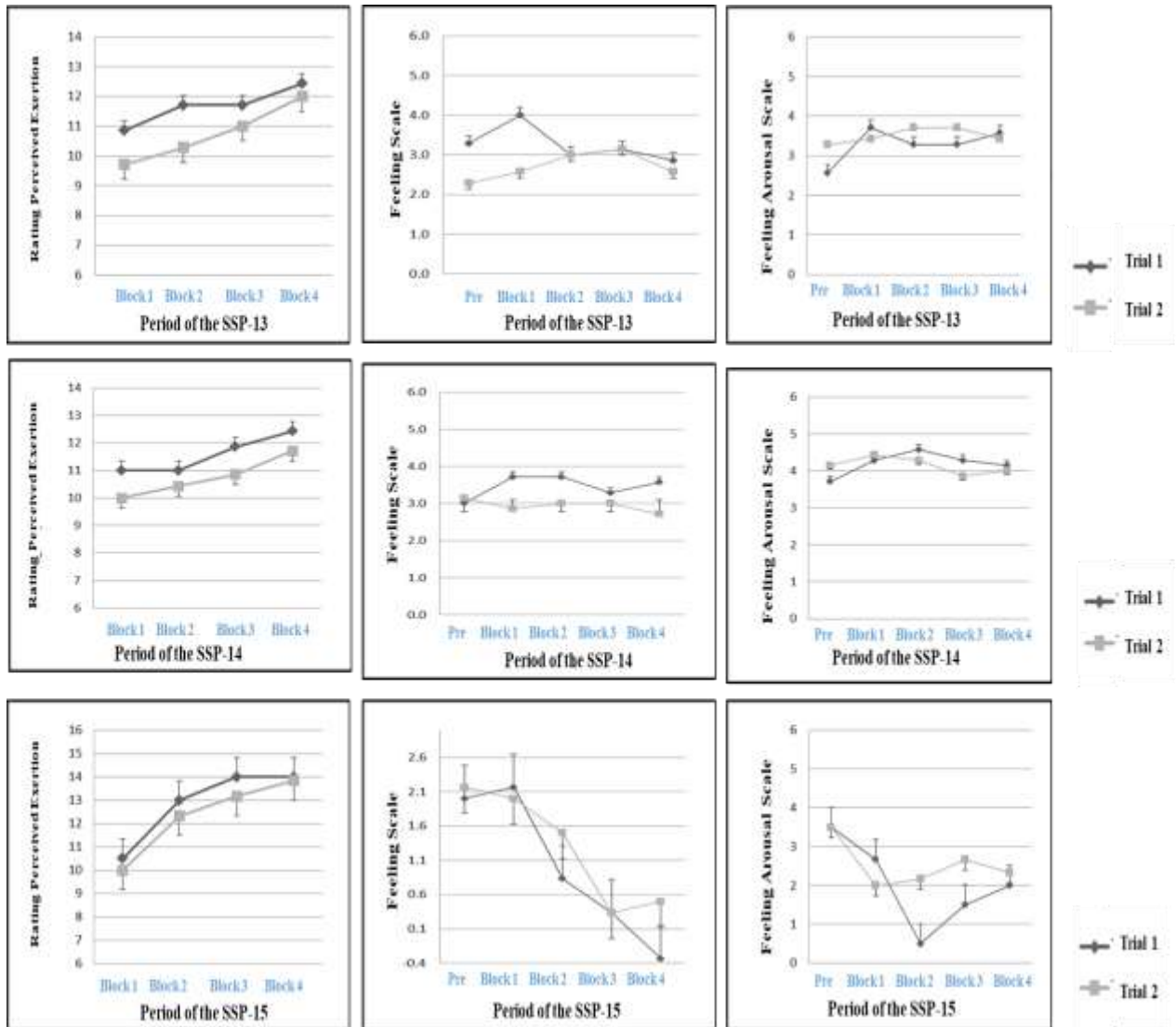
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Fig. 4. Mean peak sprint speed (km.h<sup>-1</sup>) in SSP-13, SSP-14 and SSP-15



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Fig. 5. The perceptual scales between trials in SSP-13, SSP-14, and SSP-15

## 336 5 Discussion

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The primary aim of this study was to assess the reliability and validity of three related soccer simulation protocols for use with young soccer players aged 12-15 years old. The main findings of this recent study approved the new SSPs is reliable and valid representation of youth soccer. Therefore, it could be used to investigate young players exercising with prolonged intermittent exercise activities that were similar to the demands found in match play. Although it is difficult to simulate every physical and physiological demand in soccer, this new SSPs tries to replicate as close as possible the actual match play and tries to minimize the limitations exhibited by previous protocols that have been set up for both adult or young players. The SSPs attempts to simulate the duration, distance covered, match running patterns and speed, number of sprints, sprint distance and physiological responses seen in actual match play. The development of this protocol included attempts to simulate the important components found in a soccer match encompassing both aerobic and anaerobic demands. During prolonged soccer match play, the key factors to performance is the ability to sustain prolonged intermittent running and perform repeated sprints or high intensity activities. As has been discussed earlier, in the literature, about 90% of demand in soccer is from aerobic activities and about 10% is from anaerobic activities [40].

The reliability of this new protocol was established through the conduct of two main trials separated by a period of 7 days. This allowed sufficient time for players to rest between trials and this time frame was in line with other reliability studies that examined the repeatability of similar new protocols [22], [23]. It was found no differences in BM loss, USG, RPE, FAS, FS CMJ, peak sprint speed and HR between these two trials This supports the hypothesis mentioned earlier that physiological and physical measurements could be similar between trials. Trend showed that HR and RPE increased, and sprint decreased towards the end of the protocols as was expected. There was a linear progressive increase in RPE and HR and decreases in sprint seen in both trials and this indicated that there was a similar internal load throughout of the exercise performed. This trend was also reported in other studies where it was found that HR and RPE both increased:  $115 \pm 5$  to  $165 \pm 9$  beats.min<sup>-1</sup> and 11 to 17 [41] and 160 to 200 beats.min<sup>-1</sup> and 12 to 18 respectively [42] with a few other studies reporting an increment in HR throughout the protocol [22], [43], [44]. In these protocols, the speed data was attained through maximum speed effort performed by the participants and their actual data was recorded using a 5 Hz GPS unit carried by each of them. The decrement seen in sprint performance is typically observed in soccer match play and this is also in line with other protocols such as the BEAST<sup>90</sup> [27] and the original Loughborough Intermittent Shuttle Test [22]. These suggest that the SSPs induce a similar physiological load to soccer match play and consistent when the SSP's perform repeatedly. Nevertheless, it was observed the mean HR and peak sprint speed was slightly low compared to the match data, which can be justified because there is no involvement of the ball or game situation such as attacking or defending [2]. We also had included the sideways and backward running (3-4%) time spent in this activities to add novelty in this SSP. To date, no single simulation protocol was found to be valid and reliable

381 and has been developed directly from match analysis data in young soccer players. The  
382 replication of suitable match activities and their associated physiological load in con-  
383 junction for a youth football protocol has so far been unsuccessful as previous protocol  
384 that been used to investigate young players is a modified version of adult protocol.  
385 These constraints include; did not replicate the playing duration in the actual football  
386 matches, the protocol was not develop from match analysis data to replicate the physical  
387 and physiological demands of youth football, lack of ecological validity in the protocol,  
388 no reliability or validity information have been disclosed despite these two components  
389 being essential in performance testing [2].

390  
391 Overall, the SSPs showed moderate to excellent test-retest reliability for all variables  
392 apart from FS ratings for SSP-U14 and HR in SSP-U15. Further assessment of the re-  
393 liability was determined by SEM and 95 % CI analyses. These two analyses were sug-  
394 gested by several other researchers for use in determining reliability [39], [45]. When  
395 the scores of SEM were small or equal to 0, then the test is considered to be reliable. In  
396 this present study the SEM values were found to be from 0.01 to 0.8 (except for the HR  
397 in the U15 was 1.1), thus indicating small values and thereby supporting that the pro-  
398 tocol was consistent and repeatable.

399  
400 The development of the SSP has several important purposes as research tools. It is  
401 now possible to investigate this specific age group using a reliable and valid protocol.  
402 At present, there is limited studies investigating the effects of various ergogenic  
403 aids/training interventions upon soccer performance (preparatory or half time strate-  
404 gies). This protocol is suitable for the examination of young soccer players because it  
405 has reasonably similar specific movements such as repeated sprint movements, inter-  
406 mittent running and may include specific soccer skills (seen as room for improvement  
407 in the future). There has been limited research done compared to adults as there were  
408 limited tools developed that were suitable for this population. This protocol can there-  
409 fore be used when evidence is required with regards to the testing of the efficacy of  
410 treatments or interventions such as nutritional, training or other ergogenic aid interven-  
411 tions that may help improve soccer performances. With this protocol, the researcher  
412 has greater experimental control over the research participants compared to real match  
413 play and the effectiveness of treatments can be performed under controlled conditions  
414 as needed. Having evidence that carbohydrate-electrolyte (CHO-E) ingestion in adults  
415 have a significant enhancement in intermittent endurance capacity as well as better  
416 maintenance of skill and sprint performance, improved thermoregulation and reduced  
417 risk of heat injury [3], more and more people wondering if young athletes will experi-  
418 ence the same advantage of CHO-E ingestion as their adult counterparts. Data from  
419 match analysis studies of youth soccer suggest that children do not perform an abbrevi-  
420 ated version of the running demands of adults [46]. The current SSP's were devel-  
421 oped based on the match duration as determined by FIFA for the age categories. The  
422 multiple breaks represented the 15 minutes' rest duration during the half time interval  
423 in a soccer match. In the SSP's duration are represented by 4 exercise blocks separated  
424 by 3 x 5 minutes' rest breaks. These multiple breaks have been included in order to

425 provide time for the consumption of fluids and to allow time for intervention purposes  
426 (for future research).

427

428 Furthermore, this protocol may be used to test athlete readiness to return to match  
429 play following rehabilitation. The SSP's would be able expose them to sufficient levels  
430 of stress comparable to typical soccer match-play and could provide an indication of  
431 their current soccer specific fitness level. Also, it is probably useful in the assessment  
432 of athlete readiness following rehabilitation (especially for knee injuries), return to  
433 play, as this protocol includes turning and changing direction while running and would  
434 result in the injured player experiencing similar demands to match-play but in a non-  
435 contact and controlled setting [47] . It could also be a test battery for talent identification  
436 purposes or as an evaluation tool when selecting young players as a means to assess a  
437 player's readiness and thus provide feedback to both players and coaches by quantify-  
438 ing their performance capability in the context of each individual player's strengths and  
439 weaknesses.

440

441 The advantages of this current SSP's that it is easy to replicate and be set up  
442 by future researchers or for use by coaching staff in a soccer team. Limited tools and  
443 equipment are needed and no complicated software is required, therefore this makes  
444 the SSPs easily accessible at different levels of soccer play. Moreover, the SSPs can be  
445 1) performed indoors (researchers can control environmental conditions) or outdoors  
446 (natural grass or artificial surface), and players can wear their regular soccer footwear);  
447 2) peak sprint speeds can be measured either using sprint gates, stopwatches or with  
448 GPS. With sprint gates, 1 to 4 participants can be tested simultaneously while GPS  
449 would offer more accurate data collection and more participants measured at any time  
450 throughout the protocol. For these reasons, these SSP's provides a practical method that  
451 is both sufficiently accurate and reliable for assessing young soccer players.

452

### 453 **Conclusions**

454 In conclusion, these SSPs replicate as close as possible the typical movement  
455 patterns and replicate similar physiological response in soccer match play in young  
456 players (aged 12-15 y). Simulating the same variables in soccer match-play into a stand-  
457 ardis protocol is quite challenging as there are many other variables should be included  
458 such as ball involvements, physical contacts with opponents or other psychological  
459 stress during match play. Limitation to this current protocol that can be improved by  
460 future study is to include passing, dribbling and shooting in these SSPs, therefore may  
461 enhance the ecological validity of this protocol.

462

463

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