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Kicking velocity and effect on match performance when using a smaller, lighter ball in women's football

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Abstract:	The present study evaluated the effect of a smaller, lighter ball on kicking speed and technical-tactical and physical match performance in high-level adult female footballers. In the laboratory test setting, the peak ball velocity was 6% higher with the new ball (NB) than the standard ball (SB) (26.5±0.5 vs 25.1±0.5 m·s-1, p<0.05). However, during match-play, no differences were observed in mean heart rate (87±5 vs 87±5%HRmax; p >0.05), blood lactate (90 min: 4.7±1.7 and 4.0±1.7 mmol·l-1; p>0.05), total distance covered (10.6±0.9 and 10.4±0.8 km; p>0.05), intense running (>16 km/h) (2.08±0.42 and 1.94±0.38 km; p>0.05) and match-induced decrement in Yo-Yo IR1 performance (28 vs 31%, respectively, p<0.05) using NB compared to SB. Likewise, no difference was observed in the number of short, medium-range or long passes during matches played with the two ball types, and there was no difference in passing success rate (NB: 68±1% and SB: 68±1%, p>0.05). In conclusion, high-level adult female footballers had a higher kicking speed when using a smaller, lighter ball, but no differences were observed during match-play with the two ball types in respect of technical and physical match performance. The physical loading was high for the players when playing with both ball types.

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Abstract

The present study evaluated the effect of a smaller, lighter ball on kicking speed and technical-tactical and physical match performance in high-level adult female footballers. In the laboratory test setting, the peak ball velocity was 6% higher with the new ball (NB) than the standard ball (SB) (26.5±0.5 vs 25.1±0.5 $m \cdot s^{-1}$, $p<0.05$). However, during match-play, no differences were observed in mean heart rate (87±5 vs 87±5%HR_{max}; $p>0.05$), blood lactate (90 min: 4.7±1.7 and 4.0±1.7 $mmol \cdot l^{-1}$; $p>0.05$), total distance covered (10.6±0.9 and 10.4±0.8 km; $p>0.05$), intense running (>16 km/h) (2.08±0.42 and 1.94±0.38 km; $p>0.05$) and match-induced decrement in Yo-Yo IR1 performance (28 vs 31%, respectively, $p<0.05$) using NB compared to SB. Likewise, no difference was observed in the number of short, medium-range or long passes during matches played with the two ball types, and there was no difference in passing success rate (NB: 68±1% and SB: 68±1%, $p>0.05$). In conclusion, high-level adult female footballers had a higher kicking speed when using a smaller, lighter ball, but no differences were observed during match-play with the two ball types in respect of technical-tactical and physical match performance. The physical loading was high for the players when playing with both ball types.

Key words: Foot velocity, heart rate, lactate, locomotor activities, ball velocity, passes, success rate

Introduction

Football is one of the world's most popular sports, with billions of spectators and more than 240 million football club members worldwide, of which almost 22 million are women FIFA. http://web.archive.org/web/20060915133001/http://access.fifa.com/infoplus/IP-199_01E_big-count.pdf. 2006. There are anthropometrical and physiological differences between female and male footballers. Female footballers have a lower maximal running speed, jump height and maximal oxygen uptake [13,17] and are shorter and lighter [9]. As such, these factors might not affect female match performance, since the members of an opposing team have the same capacities. In recent studies comparing male and female elite players, it was found that there are aspects of match performance that differ between genders [4,8]. Female players have a much higher number of short passes and fewer losses of ball possession. Based on the anthropometrical differences between genders, it can be argued that the size and mass of the ball should be lower in women's football, yet the same types of ball are used in international male and female football. In a study of young women, it was shown in a laboratory experiment that the maximal kicking velocity was 4% higher with a smaller, lighter ball (circumference 0.64 m, mass 0.36 kg) than with a standard ball (circumference 0.69 m, mass 0.43 kg) [1]. However, when matches played with the smaller, lighter ball were compared to matches played between the same teams with the standard ball, the only differences observed were that the lower-limb rating of perceived exertion (RPE) was lower with a smaller, lighter ball, whereas no differences were observed in the number of long or short passes, crosses or shots at goal or in the success rate. Likewise, no differences were observed in the players' running activities or heart rates. Based on that study, it can be argued that very few differences are brought about by changing the ball type. However, the subjects were young sub-elite players and it could be possible that these players did not have the skills or experience to adapt to playing with a different ball offering the potential for longer, faster shots and passes. It would therefore be of great interest to carry out similar investigations for adult high-level female players. Accordingly, the aim of the present study was to evaluate whether the introduction of a smaller, lighter ball had an effect on kicking velocity and physical and technical match performance in high level adult female footballers.

Methods

Subjects

A total of twenty-seven female football players from three teams gave their written informed consent to participate in the study.

Twelve of the players played in the best league in Denmark and had been playing for 15.5 years (12–20 years). They typically trained 4.5 hours per week and played one match per week. They gave their informed consent to participate in the kicking experiments, which involved kicking with both a standard ball (SB_1; Select Brillant Super, Select Sport A/S, FIFA standard size 5, circumference 69 cm, mass 0.445 kg, pressure 0.9 bar) and a new ball developed for female play (NB; Sensational1, circumference 64 cm, mass 0.360 kg, pressure 0.8 bar), which the teams used in training sessions for two weeks. Mean age, height and body mass were 22±2 (±SD) (range: 20–26) years, 1.69±0.07 (1.55–1.80) m and 61±7 (49–72) kg.Another fifteen players were outfield players in the second (Fløya IF) and third (Tromsdalen) best leagues in Norway and had been playing football for more than 10 years. They played two games (11v11) against each other, i.e. one game with the standard ball (SB_2; Puma, pwr-c 1.10, FIFA standard size 5, circumference 69 cm, mass 0.445 kg, pressure 0.9 bar) and another with the new ball (NB), with one week separating the games. The familiarisation period with NB was two weeks. Both games were played on artificial grass with the same referees. At the time of the experiment, the players were practicing 4–5 times per week and playing one match per week. Technical-tactical and physical match performance were measured during the games. Mean age, height and body mass were 21±6 (±SD) (15–32) years, 1.70±0.07 (1.55–1.78) m and 62±7 (51–73) kg, respectively. Written informed consent to participate in the study was obtained from the players, and meets the ethical standards of the International Journal of Sports Medicine [10].

Kicking velocity

Kicking velocity was tested in a randomised order with NB and SB_1. Twelve elite players took part in the kicking analyses. During the experiments, performed in an indoor gym, the subjects wore the same type of indoor football shoes (Puma ESITO XL, Herzogenaurach, Germany) to minimise the effect of shoe type on the results. After a 10-min light warm-up, including test kicks, the subjects were instructed to perform five maximal velocity instep kicks with each of the two balls. For the purpose of standardisation, all the subjects used a three-step approach at an angle of 22.5–45.0 degrees, which was marked on the floor. To be valid, a kick had to hit a target of 1x1 m starting 0.15 m above the floor and attached to a net 4 m away from the ball. The order of testing was randomised between subjects. Three spherical reflective markers were attached in a triangle to each of the two balls. Four other markers were attached to the hip (Trochanter Major), knee (Condylus Lateralis Femoris), ankle (Malleolus Lateralis) and toe (Caput Metatarsalis V) of the kicking leg of each participant. The three-dimensional motion of the markers was recorded with an eight-camera opto-electronic system operating at a frame rate of 500 Hz (ProReflex MCU1000, Qualisys Medical AB, Sweden). The geometrical centre of the ball was calculated from the three markers placed on the surface of the ball [3]. The beginning of the impact was determined as the first frame in which the ball showed positive acceleration. V_{ball} was defined as the average resultant velocity over ten frames, starting 16 ms (eight frames) after the beginning of the impact, since the duration of the impact period is between 10 and 13 ms [11,15]. Displacement data from the leg were filtered using a fourth-order Butterworth low-pass filter (75 Hz, determined by residual analysis) with zero degrees phase lag [20], from 70 ms before impact until the last frame before impact. Before filtering, the ends of the signal were extrapolated by 50 data points by mirroring in both vertical and horizontal directions, so the position and slope of the original and the extrapolated sequence were matched at the end-point [19]. After filtering, the extrapolated sequence was removed. From the filtered displacement data, the velocity of the foot was determined at the last frame before impact as the velocity of the centre of mass of the foot at the midpoint between the two markers placed on the foot. The velocity of the knee was determined as the velocity of the knee marker at the last frame before impact. To quantify the transfer of velocity from the foot to the ball, the ratio between ball velocity after impact and foot velocity before impact (k) was calculated. Furthermore, the coefficient of restitution was calculated using the formula in Bull Andersen et al. [2] and anthropometrical data from Winter [20]. The kicking distance was estimated by calculating the horizontal distance of the ball when projected at an angle of 26 degrees. These calculations did not include possible effects of aero dynamical drag and lift.

HR monitoring

Before the games, heart-rate monitors were placed around the chest (Polar Team 2 System, Polar Electro Ov, Kempele, Finland). The heart rate chest strap, including the heart-rate monitor, weighs less than 100 g and allows the players to move freely. Heart rate was recorded in 5-s intervals during each game and during the Yo-Yo IR1 tests using short-range radio telemetry. Mean heart rate values were calculated in absolute (bpm) and relative (%HR_{peak}) terms. Heart rate distribution, expressed as percentage of total time, was also calculated. Peak heart rate (HR_{peak}) was determined as the highest heart rate achieved in either the Yo-Yo IR1 tests or the games. The games lasted 2x45 min with a 15-min half-time interval.

Activity pattern

The activity pattern of the players was monitored using the ZXY-Sport Tracking System (ZXY, Trondheim, Norway). Each player wore a belt with an electronic sensor system at the player's lumbar. The ZXY system uses the 2.45 GHZ ISM band for radio communication and signal transmissions. All stationary sensors (10) are interfaced to the data infrastructure using standard TCP/IP Ethernet connections. The stationary sensors compute the position data for each belt on the field by providing advanced vector-based processing of the received radio signals. The processing system in each stationary sensor enables direct projection of the player's positions on the field without the use of conventional triangulation methods. The default resolution is fixed at 20 Hz for each belt [7,18]. High-intensity running (HIR) was defined as speed >16.0 km·h^{-1} and sprinting as speed >20.0 km·h^{-1}. Acceleration counts were defined as a positive or negative change in speed of more than 2 m·s^{-2} over a period of more than 0.5 s. After the games, the data were downloaded to a computer and analysed. Total distance, acceleration counts and distance covered in walking (<7.0 km·h^{-1}), jogging (7.0–12.0 km·h^{-1}), running (12.1–16.0 km·h^{-1}), HIR (16.1–20.0 km·h^{-1}) and sprinting (>20 km·h^{-1}) were measured.

Technical analysis

Both games were recorded using a digital video camera (Canon HF20E, Canon, Tokyo, Japan). The camera followed the ball, filming an area of 20x20 m around the ball. The technical actions were analysed by InStat (Moscow, Russia). It was registered every time a player was in contact with the ball during the game. The ball contact was separated into passes, interceptions, tackles, headers, shots, throw-ins, free-kicks and corner-kicks.

Yo-Yo IR1 testing

The players performed a Yo-Yo Intermittent Recovery level 1 test (Yo-Yo IR1) to determine intermittent exercise capacity at rest and after the games. The Yo-Yo IR1 consisted of a 10-min standardised warm-up followed by 2x20-m repeated shuttle runs back and forth between the start and finish lines. The speed increased progressively and was controlled by audio beeps from a CD player. Between each running bout, the participants had a 10-s active recovery period in which they jogged around a cone placed 5 m behind the finish line. The test result was noted as the running distance at the second time the participants failed to reach the finish line in time.

Blood lactate

Lactate concentration was measured using hand-held portable analysers (Lactate Pro, Arkray, KDK, Japan) and determined from 5-μL samples taken from the index fingertip in a rested state prior to the warm-up as well as pre game and post first and second halves. Additionally, lactate concentration was determined after the Yo-Yo IR1 test following the games.

Fluid intake

The players' body weights were measured before and after the games, while their water intake during the games was recorded.

Statistical analyses

Data were analysed using SPSS 21.0 for Windows (SPSS Inc., Chicago, IL, USA). All results are presented as means±*SEM* unless otherwise stated. Differences in physical and technical-tactical performance and in heart rate data during and between the competitive matches as well as differences in blood lactate values were determined by a two-way analysis of variance (ANOVA) with repeated measures. Data were subsequently analysed using a Bonferroni post-hoc test. Differences in variables for kicking velocity, match activity and ball management as well as post-match Yo-Yo IR1 performance and post-match body weight between conditions were determined using Student's paired two-tailed *t*-test. A significance level of 0.05 was chosen.

Results

Kicking velocity

The ball speed was 6% higher when kicking the smaller, lighter ball (NB) than when kicking the standard ball (SB_1) (26.5±0.5 vs 25.1±0.5 $m{\cdot}s^{-1}$, $p<0.001$; Fig. 1). There was no difference in the velocity of the foot when kicking NB compared to SB_1 (19.2±0.3 and 19.6±0.2 $m{\cdot}s^{-1}$, respectively, $p>0.05$; Fig. 1). The ratio between ball and foot velocities was higher for NB than for SB_1 (1.38±0.02 vs SB_1 1.28±0.02, $p<0.001$).

Heart rate during match-play

During match-play, no differences were observed when using NB compared to SB_2 in terms of mean HR (87±5 and 87±5%HR_{peak}, n=15, $p<0.05$) or HR_{peak} (190±8 and 190±8 bpm, n=15, p<0.05). There were no differences in heart rates between the first and second halves of the games played either with NB (88±5 and 87±5%HR_{peak}) or SB_2 (87±5 and 87±6%HR_{peak}). HR_{peak} in the Yo-Yo IR1 test after games using NB and SB_2 was 194±5 and 195±6 bpm, respectively, p>0.05 (Table 1).

Yo-Yo IR1 testing before and after games

The distance covered in the Yo-Yo IR1 (n=14) was 1480±396 m at rest, which was significantly greater than after both NB and SB_2 games (1064±385 and 1025±337 m, respectively, p<0.05), with no difference in the game-induced decrement between NB and SB_2 (28 and 31%, respectively, p>0.05).

Match activities

No difference was observed in total distance covered during games with NB and SB_2 (10.6±0.9 and 10.4±0.8 km, respectively, n=15, p>0.05). There were no differences between games with NB and SB_2 in any of the speed categories, i.e. walking, jogging, running, HIR and sprinting (see Table 2). There were significant differences in the distances covered in HIR and sprinting in some of the six 15-min periods between the two games, but the total distances in these categories were not different between games with the two ball types (Fig. 2). There were no differences between ball types in the number of occurrences of HIR and sprinting (Table 3).

Technical analysis

There were no differences (p>0.05) in short, medium-range and long passes in games with the two ball types (Table 4) or in the passing accuracy in games with NB and SB_2 (68±1 and

68±1%, respectively, $p>0.05$). There were no differences in the total number of shots per player (1.6±1.6 and 1.4±1.8, respectively, $p>0.05$) or the number of shots on target per player (0.8±1.1 and 0.8±1.3, respectively, $p>0.05$) in games with NB compared to SB_2. No differences were observed in games with NB and SB_2 in the number of tackles per player between the two games (6±4 and 6±3, $p>0.05$), whereas fewer interceptions were observed in games with NB compared to SB_2 (5±3 vs 8±5, $p<0.05$). There was no difference in headers per player during games with NB and SB (3±3 and 4±3, $p>0.05$). The total number of throw-ins, crosses and aerial corners was 56, 22 and 7 in the NB game and 46, 20 and 6 in the SB_2 game (Table 5).

Blood lactate

There were no differences in blood lactate before and during games played with NB and SB_2 (Table 1), with values of 4.7±1.7 and 4.0±1.7 mmol/l, respectively, immediately after the second half (n=7; $p<0.05$). Blood lactate was higher after the Yo-Yo IR1 test performed after the game played with NB compared with the game played with SB_2 (10.2±1.5 vs 8.1±1.5 mmol/l, $p<0.05$).

Fluid loss

No differences ($p>0.05$) were found in weight loss during games with NB (61.3±6.9 to 60.5±6.8 kg) and SB_2 (61.9±6.8 to 61.0±6.9 kg), nor in fluid intake (0.55±0.26 and 0.62±0.33 l). The calculated in-game fluid loss with NB and SB_2 was therefore 1.4±0.5 and 1.5±0.6 l, respectively, $p>0.05$).

Discussion

The main findings of the present study were that, although high-level adult female footballers were able to kick 6% faster with a smaller, lighter ball under laboratory conditions, the locomotor activities and physiological response were unaffected by ball type and there were no effects on technical match performance. These findings are in line with observations in young female players [1].

For the investigated high-level adult female footballers, the ball velocity was 6% higher when performing maximal kicks with the smaller, lighter ball in the laboratory setting, corresponding to a difference of 5 km/h (95.4 vs 90.4 km/h) between the new ball and the standard ball. Based on these initial ball velocities, it can be estimated that the maximal kicking distance would be around 50 m with the smaller, lighter ball and around 45 m with the standard ball, and that the smaller, lighter ball would cross the goal line 0.19 s faster (13%) than the standard ball when shot from a distance of 25 m. However, this comparison is limited by the kicking experiments being performed in an indoor laboratory. There is, however, no scientific evidence, that kicking velocity differs between kicks performed outdoor with studded soccer shoes and indoor with soccer shoes with outsoles made of rubber.

The observed differences in kicking velocities for the two ball types for the investigated high-level female footballers are slightly greater than the differences observed in a previous study from our laboratory with young female players (4%; [1]), with kicking velocities 12% higher with the standard ball for adults vs young female players (90.4 vs 80.6 km/h) and 14% higher with the smaller, lighter ball (95.4 vs 83.5 km/h). As for the young female players in the study by Andersen et al. (2012), no differences were observed in foot velocity when kicking the two ball types in the present study, meaning that the differences in kicking velocity are related to the lower mass of the new ball, as shown by the higher ratio between ball and foot velocity.

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Despite the observed differences in the laboratory test results for the two ball types and the potential for faster kicks and longer kicking distances with the smaller, lighter ball, we found no differences in the numbers or types of passes, the success rate of passes, the locomotor activities or the physiological demands during games played with the two ball types for high-level female players. The technical-tactical analyses of the high-level adult female footballers in the present study showed a higher number and higher success rate of passes compared to the previous investigations on young female players [1], with values comparable to male football games on artificial turf [4]. However, very similar values of 43 and 44 passes per player and success rates of 68 and 68% were found for the matches with the new ball and the standard ball. Likewise, there were no differences in the number of shorts on target, crosses, aerial corners, number of headers, number of attacking passes behind the defence line or overall length of passes when the female footballers played with the two ball types. The only difference observed between matches was that fewer interceptions were made in the match with the smaller, lighter ball (5 vs 8 per player), and it may be speculated that this is due to the higher ball speed, although the overall success rate was unaltered. When looking specifically at length of passes, it is interesting to see that as many as 96% of all passes during games with both ball types were short or medium-range (<40 m) and only 1.2 and 1.6 passes per player per game were long passes (>40 m) (see Table 4). The type of game that is being played by women in many leagues, with a focus on possession with many ball touches, many short passes and a relatively high success rate [1,3] may be one of the main reasons why we were unable to detect any differences in technical-tactical performance when introducing the smaller, lighter ball. Hence, if the players are rarely trying to kick as fast or as far as they can, they are rarely limited on that parameter, and an increase in maximal kicking distance from 45 to 50 m through a change of ball does not seem to be affecting the game that much. Although the adult female footballers have much more experience, a higher level of play with a higher success rate of technical actions and more emphasis on the heading game than the previously investigated young female players, there are basically no differences in the way that the teams manage with the new ball.

Some aspects to consider are whether the differences in ball characteristics are large enough markedly to influence the range of possibilities, whether faster and longer kicks were performed at the expense of technical control and whether the games were played at a sufficiently high tempo to stress the importance of fast and long passes and shots. No differences were observed in the success rate of any of the technical actions, which speaks against any lack of technical control with the new ball. Nonetheless, it cannot be ruled out that the players were not sufficiently confident about ball control to use their longest possible passes or fastest possible kicks on goal, and that a period of familiarisation longer than 2 weeks would have been beneficial. Another important matter to consider is whether the investigated matches were of sufficiently high intensity to challenge the players and to make them strive for the fastest possible play in situations of high pressure. The analyses of locomotor activities and physiological response clearly showed that this was the case. For example, the total distance covered in the games was ~10.5 $km \cdot h^{-1}$ and average heart rates were 87–88% of individual maximal heart rate, which is comparable to studies of Scandinavian elite female footballers during competitive games [12] and friendly games [6,12,14]. Actually, the players in the present study performed more high-intensity running and sprinting than in previous investigations of Scandinavian elite players, but this may be due to differences in cut-off points as well as methodologies for determining high-speed running [18]. In further support of a high tempo in the investigated games are the findings of match-induced fatigue, with a 30% decrease in intermittent exercise capacity when performing Yo-Yo IR1 testing after compared to before the games, and similar decrements in high-intensity running and sprinting during the last compared to the first 30-min periods of the games. Similar changes in intermittent exercise capacity

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have been observed in a variety of studies in highly demanding elite female competitive as well as friendly games [5,12,14,16].

Another important finding related to the comprehensive measurement of locomotor activities, fatigue development and physiological demands was that no changes were observed when introducing the smaller, lighter ball. Actually, distance covered (10.6 and 10.4 km), average heart rate (170 and 169 bpm), fluid loss (1.4 and 1.5 l) and game-induced lowering of Yo-Yo intermittent exercise performance (28 and 31%) were surprisingly similar in the games with the two ball types, and furthermore no significant differences were observed in high-intensity running and blood lactates. These findings of similar scores for locomotor activities, fatigue development and heart rate are identical to the observations in the study of young female players [1]. Considering that any major changes in technical-tactical performance in games played with the smaller, lighter ball, such as faster play, more attacking passes behind the defence line, more defence-to-attack kicks and rush passes, etc., would be expected to influence certain physical parameters such as number of sprints or headers, the lack of differences seems to support the notion that the new ball had little impact on the female game, even when played with a high tempo by experienced high-level female footballers. Nonetheless, it is important to consider the risk of a statistical type 2 error when relatively few players are investigated and only two games are compared, in contrast to the previous study with young female players. In light of this, it is noteworthy that the average distance covered by high-intensity running above 16 km/h was 7% higher for the 15 investigated players when playing with the smaller, lighter ball and that the average distance covered by sprinting (>20 km/h) was 11% higher. So it cannot be ruled out that introducing the smaller, lighter ball had some effects that were just not big enough to be detected with the design of the present study. However, the lack of differences in the types of passes, shots on goal and number of headers, combined with the fact that seven of the investigated players performed most sprinting in the game with the standard ball, underlines that introducing a smaller, lighter football has no systematic and revolutionary effects on match performance in high-level adult female footballers.

The present study revealed that, under laboratory conditions, peak kicking velocity can be increased significantly for high-level adult female footballers with a smaller, lighter ball. It was also observed that, despite the potential for faster and longer passes and shots when using the new ball in a game situation, no differences were found in technical-tactical match performance, locomotor activities, game-induced fatigue or physiological response for high-level adult female footballers playing high-tempo match-play. These findings were very similar to what we previously observed for sub-elite U18 girls and suggest that there are no immediate effects on match-play for female footballers by introducing a lighter, smaller ball. However, future studies are needed in order to investigating whether long-term practise with a smaller, lighter ball could change the style of match-play of female footballers by making the players utilizing the possibility of making longer and faster passes and shots.

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Table 1. Lactate and heart rate (HR) before, during and after games played with the new ball (NB) and the standard ball (SB).

	Rest		Pre game		Post first half		Post game		Post Yo-Yo	
	NB	SB	NB	SB	NB	SB	NB	SB	NB	SB
Lactate (mmol/l)	1.3±0.2	1.2±0.2	2.1±0.3	2.1±1.1	4.8±2.5	3.0±0.9	4.7±1.7	4.0±1.7	10.2±1.5*	8.1±1.5
HR_{peak} (bpm)					192±8	190±8	190±8	190±10	194±5	195±6
HR mean (bpm)					171±11	169±11	169±8	169±13		
% HR_{peak}					88±5	87±5	87±5	87±6		

*Significantly different between games. Data are means±SD for n=15, except blood lactate (n=7).

Table 2. Total distances covered in the different speed categories (m) and acceleration counts (n=15).

Walking >7.0 km/h		Jogging 7.1–12.0 km/h		Running 12.1–16.0 km/h		High-intensity running 16.1–20.0 km/h		Sprinting >20.1 km/h		Acceleration counts *n*	
NB	SB	NB	SB	NB	SB	NB	SB	NB	SB	NB	SB
3645±316	3617±293	3982±650	3981±616	1394±381	1379±404	1531±389	1436±308	552±220	498±150	180±33	161±31

Data are means±SD

Table 3. Activity changes in the HIR and sprinting categories.

High-intensity running bouts (n)		Sprinting bouts (n)	
NB	SB_2	NB	SB_2
86±21	80±18	12±7	10±6

Data are means±SD (n=15).

Table 4. Number of passes and the success rate (%) per player during games played with the new ball and the standard ball.

	Total		Short (0–10 m)		Med.-range (10–40 m)		Long (>40 m)	
	Number of passes	Success rate (%)	Number of passes	Success rate (%)	Number of passes	Success rate (%)	Number of passes	Success rate (%)
NB	43±15	68±9	9±4	69±17	32±13	70±8	2±2	36±32
SB	44±13	68±11	11±4	70±18	32±12	68±12	1±1	38±42

Data are means±SD (n=15).

Table 5. Number of occurrences and set pieces during the games with the standard ball and the new ball.

	NB	SB_2
Shots (per player)	1.6±1.6	1.4±1.8
Shots on target (per player)	0,8±1.1	0,8±1.3
Tackles (per player)	6±4	6±3
Headers (per player)	3±4	4±3
Interceptions (per player)	5±3*	8±5
Throw-ins (n)	56	46
Crosses (n)	22	20
Aerial corners (n)	7	6
Attacking passes (n)	35	34

*Significantly different from SB. Data are means±SD (n=15)

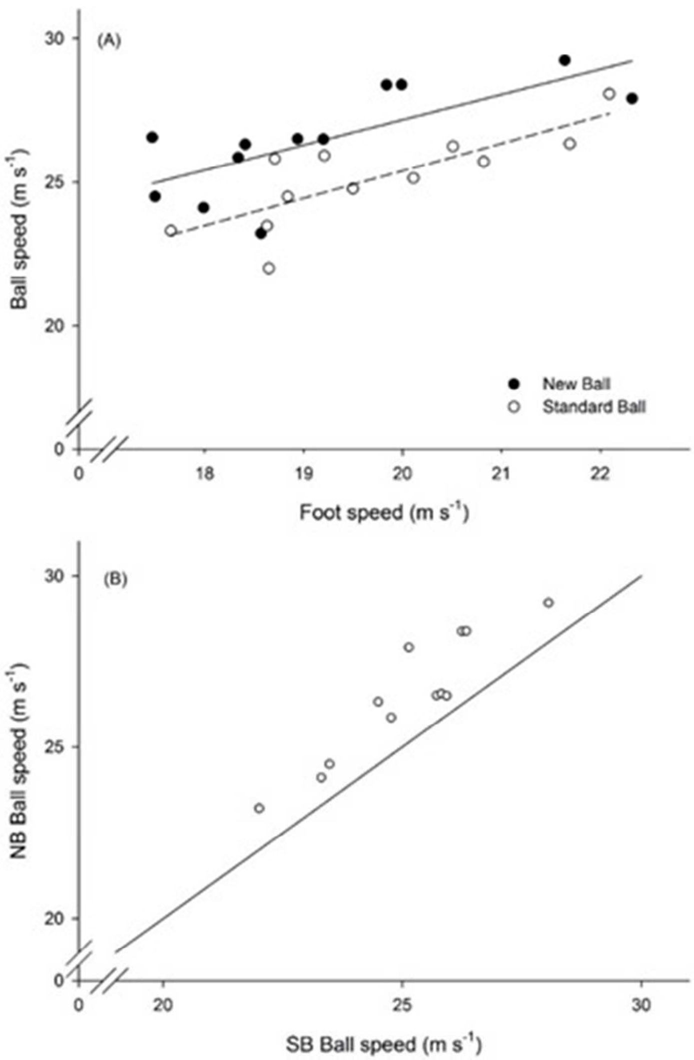

Figure 1.\r\nA) Ball velocities plotted as a function of their corresponding foot velocities for 12 adult female elite players. Kicks with the new ball (NB) are marked by filled circles (●) and kicks with the standard ball (SB) are marked by open circles (○). The solid line is a linear regression on the kicks with the new ball and the dashed line on kicks with a standard ball, B) Ball velocities of kicks with the new ball (NB) plotted as a function of ball velocities of kick with a standard ball (SB) for adult female elite players. The solid line is a line with direct proportionality, $V_{NB} = V_{SB}$.\r\n
100x118mm (120 x 120 DPI)

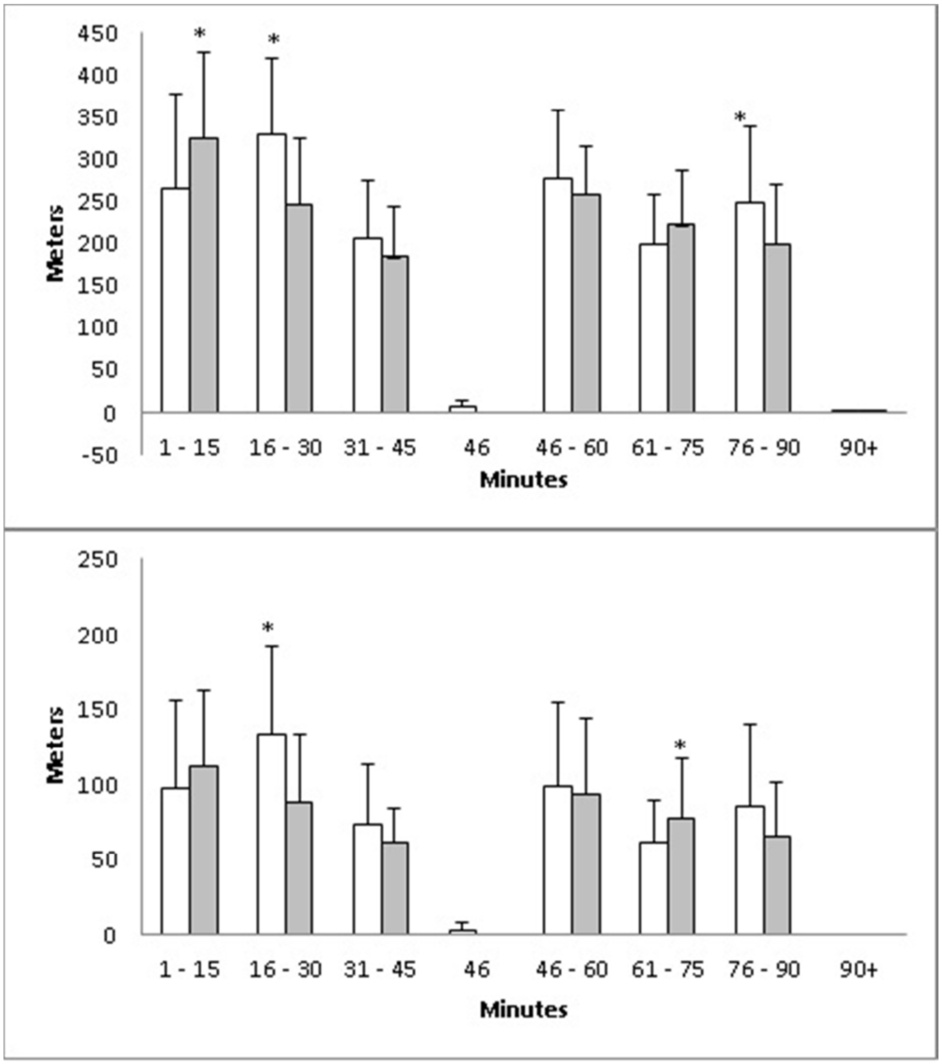

Figure 2.
High-intensity running distance (A) and sprinting (B) in 15-min periods of the games played with the smaller, lighter ball (NB, white bars) and standard ball (SB, grey bars). Data are means±SD (n=15). *Denotes significant difference between NB and SB in in the same 15-min period.

98x112mm (120 x 120 DPI)