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PII: S0378-3782(25)00034-9

DOI: https://doi.org/10.1016/j.earlhumdev.2025.106224

Reference: EHD 106224

To appear in: *Early Human Development*

Received date: 6 January 2025

Revised date: 18 February 2025

Accepted date: 18 February 2025

Please cite this article as: J.T. Manning, K. Parpa, L. Mason, et al., Is digit ratio (2D:4D) a biomarker for lactate in women? Evidence from a cardiopulmonary test on professional female footballers, *Early Human Development* (2024), https://doi.org/10.1016/j.earlhumdev.2025.106224

# Is digit ratio (2D:4D) a biomarker for lactate in women? Evidence from a cardiopulmonary test on professional female footballers

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**Abstract**

*Background:* Lactate and digit ratio (2D:4D) have been linked to sports performance, cardiovascular disease, and some cancers. 2D:4D is strongly and positively associated with lactate during exercise across a range of running speeds in men. This study aimed to consider the relationship between 2D:4D and lactate in women during an incremental cardiopulmonary exercise test.

*Method:* The participants were professional female football players. The treadmill test began at a speed of 6km/h and was increased by 2km/h every 3.15 minutes, with measurements at 6, 8, 10, 12, and 14 km/h.

*Results:* There were 25 Caucasian and 3 Black participants; 2D:4D and lactate levels were lower in the latter, but the sample size was too small for meaningful comparisons. Lactate levels increased with running speed. The 2D:4D was not associated with lactate at 6 to 12 km/h. At 14 km/h, lactate was positively associated with right and left 2D:4D (stronger for the former) and negatively with height and digit lengths. These correlations were significant for the total sample and Caucasians only. Multiple regressions for the Caucasian sample showed that right 2D:4D was positively related to lactate at 14 km/h, and height was negatively associated with lactate at all speeds.

*Conclusion:* During exercise, the effect sizes for relationships between 2D:4D and lactate in women are positive but smaller than those reported for men and restricted to higher running speeds. Unlike men, women show a negative relationship between height and lactate. It is suggested that prenatal and pubertal sex steroid effects may explain these sex differences.

## Introduction

Exercise releases many signalling molecules (exerkines) that promote health and longevity [1]. Important among these is lactate, which has regulatory roles that extend beyond exercise performance and include links to vascular, cardiac, and pulmonary function and cancer biology [2]. The pattern of links between lactate and its many health-related benefits has a remarkable similarity to that of digit ratio (2D:4D), a trait that is widely thought to be a marker for prenatal sex steroids [3]. A consideration of the association of digit ratios (right 2D:4D; left 2D:4D and right-left 2D:4D [Dr-l]) with lactate levels during progressive exercise in male football players has revealed positive correlations. Of the three ratios, right 2D:4D was most strongly correlated with large effect sizes. This suggests that males who have been exposed prenatally to low testosterone and high oestrogen generate high lactate levels during vigorous exercise [3]. There is a lack of corresponding information for females. To facilitate comparisons with the earlier study on males, we consider these relationships in female footballers who undertake a similar training schedule to that of the men. The background to this comparison is best seen in the relationships between digit ratio, lactate, and exercise.

For many years lactate was regarded as a consequence of deficiency of oxygen in contracting skeletal muscle. In contrast to this view, it is now known that lactate is formed continuously under fully aerobic conditions and is the preferred substrate for mitochondrial respiration in many cell types. Thus, lactate enters the mitochondrial reticulum to support oxidative phosphorylation of adenosine diphosphate [4,5]. Exercise releases factors (exerkines) that promote health and longevity [1]. There are many such exerkines, among them, lactate is the greatest in terms of concentration and it is thought that repeated lactate exposure from regular exercise results in mitochondrial biogenesis [6].

The digit ratio, defined as the relative lengths of the second (2D) and fourth (4D) fingers, is widely recognized as an indirect indicator of first-trimester sex steroid exposure. Specifically, a lower 2D:4D ratio is associated with higher prenatal testosterone levels, while a higher ratio is linked to greater prenatal oestrogen exposure [7. 8]. Early prenatal sex steroids secreted by the mother and by the foetus bring about organizational changes in the foetus which prepares it for pubertal activational changes associated with testosterone and oestrogen [9]. There are links between lactate and testosterone. Exercise-induced testosterone secretion has been reported to be increased in rat testicular cells when cultured with lactate [10-12].

A consideration of the associations between running, lactate, and 2D:4D serves to highlight similarities between the latter two. The expression of both lactate and 2D:4D is dependent on ethnicity. East African athletes dominate high-intensity endurance running events (3,000–10,000 m). In comparisons between male Caucasian and African runners, the latter exhibit lower lactate accumulation in endurance tests [13-18]. Considering sprinting, individuals of West Sub-Saharan African ancestry are dominant in 100, 200, and 400 m. Sellami et al. (2017) [19] reported performances and lactate levels of Caucasian and Black women and men in a repeated sprint test of six 35-m sprints. Black participants had lower lactate levels compared to their white counterparts. Regarding 2D:4D, there are differences between Caucasian and Black groups, such that the latter have lower 2D:4D than the former [9]. Performance in distance races is associated with 2D:4D, such that athletes with low 2D:4D (high prenatal testosterone, low prenatal oestrogen) run faster than athletes with high 2D:4D [20, 21]. Concerning this, some studies (but not all) have reported there are significant negative correlations between 2D:4D and measures of oxygen metabolism that are important in distance running including maximal oxygen consumption [22]. Bearing in mind the difference in mean 2D:4D between Black and Caucasian groups, it is appropriate that these ethnic differences are controlled for when considering performance in aerobic exercise.

Manning et al (2024) [3] suggested that 2D:4D may be a biomarker for lactate. They considered the relationship between 2D:4D and lactate during an incremental cardiopulmonary exercise test taken by professional male football players. It was found that there were large positive associations between right 2D:4D and lactate at all running speeds. That is, males exposed to low prenatal testosterone and high prenatal oestrogen produce high levels of lactate during vigorous exercise. The digit ratio is sex dependent, with male 2D:4D<female 2D:4D. It is usual that male and female 2D:4D data are analysed separately. Therefore, it is unclear whether 2D:4D is related to lactate in females. The purpose of this report is to consider the relationship between digit ratio and lactate in females.

Given the sex differences in 2D:4D (males < females), this study aims to explore whether similar relationships exist in women. For consistency, we focus on professional female football players with training regimens comparable to their male counterparts. We hypothesize that (i) 2D:4D will be positively associated with lactate levels during incremental exercise in women, particularly at higher running speeds, mirroring findings in male athletes but with potentially smaller effect sizes, and (ii) Height and digit lengths may be negatively correlated with lactate levels during exercise, suggesting distinct physiological mechanisms in women compared to men.

**Materials and Methods**

Twenty-eight professional female soccer players participating in Division 1 in the Eastern Mediterranean were recruited for the study. The players underwent maximal incremental cardiopulmonary exercise testing on the treadmill in addition to the anthropometric measurements. The tests were conducted at the beginning of the season and after the pre-season preparation period. Prior to the exercise testing, the players underwent a four-week preparation period, consisting of five 90-minute training sessions per week and one friendly game each weekend. All the players were advised to avoid heavy physical activities the day before the testing, scheduled from 2:00 to 7:00 pm. They all had prior experience with the testing procedures and voluntarily participated in the study after signing an institutionally approved informed consent. The study was conducted following the declaration of Helsinki and received approval from the National Committee of Bioethics (CNBC).

Players who had sustained injuries within the last two months prior to data collection or did not complete the preseason preparation were excluded from the study. Additionally, goalkeepers were excluded from the statistical analysis as they had a different preseason preparation.

**Anthropometric and body composition analysis**

Stature was measured to the nearest 0.1 cm using a wall-mounted stadiometer (The Leicester Height Measure, Tanita, Tokyo, Japan). Body composition was assessed with a leg-to-leg bioelectrical impedance analyser (BC 418 MA, Tanita, Tokyo, Japan). Prior to the bioelectrical impedance testing, the players were instructed to adhere to standard guidelines, which included fasting for at least four hours, not having intense physical activity the day before the assessment, avoiding drinks with high caffeine content in the previous twelve hours, and emptying their bladder before the test.

**Hand scans**

The players' hands were scanned according to the methodology described by previous investigators [9]. The players placed their hands on the surface of an EPSON scanner (DS-50000) with the palm facing downwards and fingers as straight as possible. They were instructed to place their fingers lightly on the scanner and wait until the scan was completed. In cases where the scan was not clear, it was repeated. Digit length was measured twice by the same investigator [7], blind to the lactate data, and the 2D:4D ratio was calculated from each set of scans. Digit length was measured to an accuracy of 0.05 mm using Vernier calipers (Mitutoyo, D15, Japan).

**Incremental Cardiopulmonary Exercise Testing**

Participants underwent maximal incremental cardiopulmonary testing on a treadmill (HP Cosmos Quasar med, HPCosmos Sports and Medical GmbH, Nussdorf-Traunstein, Germany) following the methodology described by previous researchers [22]. The inclination was kept constant throughout the test at 1% [23]. The test began at a speed of 6km/h and was increased by 2 km/h every 3.15 minutes until the players reached volitional fatigue. A breath-by-breath analysis was conducted using a Cosmed Quark CPET system (Rome, Italy) in constant laboratory conditions (temperature at 22 ± 1 ◦C; relative humidity at 50%).

The players began the test at a 6km/h speed with the first lactate measurement conducted at that point. The speed then increased by 2km/h every 3.15 minutes. As a result, measurements were taken at speeds 6, 8, 10, 12, 14, and 16 km/h, although some players did not reach 16km/h. For the lactate measurements, the Nova blood lactate plus analyser (Nova Biomedical, Waltham, MA 02454) was used, which is accurate and reliable [24]. A single-use Lactate Plus test strip was touched to a drop of blood (0.7 microliters), taken via finger prick from the 3$^{rd}$ or 4$^{th}$ digit of the non-dominant hand, to initiate the test. Blood lactate values were displayed on a screen within 13 seconds. Blood samples were collected every 3 minutes after the completion of each test stage.

**Statistical analysis**

Analysis was performed using SPSS, version 28.0, for Windows (SPSS Inc., Chicago, IL, USA). The normality assumption was assessed from values of skewness and kurtosis. All parameters are presented as the mean and standard deviations, as normality was confirmed. Intra-class correlation coefficients (ICC) (absolute agreement) between the first and second

2D:4D's of the right and left digits were calculated. Pearson-product moment correlation coefficients were used to estimate associations. Correlations were calculated for speeds 6 to 14 km/h and were described as trivial (0–0.1), small (0.1–0.3), moderate (0.3–0.5), large (0.5–0.7), very large (0.7–0.9), nearly perfect (>0.9) and perfect (1.0) [25]. Multiple regression analyses were performed for speeds of 6 km/hr, 8 km/h, 10 km/h, 12 km/h, and 14 km/h. The dependent variable was lactate, and the independent variables were right 2D:4D, height, and mean right digit lengths. The level of significance was set at $p < 0.05$.

**Results**

There were 28 participants. The descriptive means [SD] for the sample were age 22.6 [4.3] years, height 163.9 [5.0] cm, body mass 59.4 [6.8] kg, and body mass index (BMI) 22.0 [2.0] kg/m$^2$.

*Digit ratios*

The repeatability for the digit ratios was high and significant for right 2D:4D ($r_1$ = .982, $F$ [1,27] = 112.34, $p$<.0001), left 2D:4D ($r_1$ = .969, $F$ [1,27] = 62.96, $p$<.0001) and Dr-l ($r_1$ = .917, $F$ [1,27] = 23.13, $p$<.0001). Thus, between-individual differences in digit ratios were significantly higher than measurement error. Therefore, we calculated the mean digit ratios (right 2D:4D, .963 [.031], left 2D:4D, .954 [.031], Dr-l .008 [.025]) and used these in all subsequent statistical analyses.

*Ethnicity*

Three participants were Black and the remainder were Caucasian. The former had significantly lower right and left 2D:4D than the latter (right 2D:4D Caucasian, $n$ = 25, .969 [.025], Black, $n$ = 3, .910 [.031], $t$ = 3.84, $p$ = .0007: left 2D:4D, Caucasian, $n$ = 25, .959 [.029], Black, *n* = 3, .913 [.021], *p* = .01, *t* = 2.65, *p* = .01). There was no significant difference for Dr-l (Caucasian *n* = 25, .009 [.026], Black n = 3, -.003 [.019], *t* = .827, *p* = .42).

*Lactate measurements*

The mean of blood lactate levels (mmol/l) increased with increasing speed: 6 km/h = 1.511 [.515], 8 km/h = 2.207 [.897], 10km/h = 3.575 [1.382], 12 km/h = 5.500 [1.796], 14 km/h = 7.927 [1.918] (Figure 1). Values of skewness and kurtosis were low varying from .029 for 14 km/h to 1.282 for 6 km/hr for skewness, and for kurtosis from -.026 for 10km/h to -.861 for 8 km/h.

In comparison to Caucasian participants, blood lactate levels were lower for Black participants, and it was significant difference at speeds of 12 km/h (*p* = .04) and 14 km/h (*p* = .0007) (6 km/h, Caucasian players 1.564 [.520], Black players 1.067 [.058], *t* = 1.627, *p* = .12: 8 km/h, Caucasians players 2.320 (.884), Black players 1.267 (.058), *t* = 2.029, *p* = .053; 10 km/h, Caucasian players 3.724 (1.389), Black players, 2.333 (.153) *t* = 1.705, *p* = .10; 12 km/h Caucasian players 5.740 (1.750), Black players 3.500 (.300), *t* = 2.177, *p* = .04; 14 km/h Caucasian players 8.348 (1.604), Black players 4.700 (.173), *t* = 3.867, *p* = .0007).

*Correlates of Lactate levels*

We calculated product-moment correlations (*r*) between lactate levels at different treadmill speeds and the following: digit ratios (right 2D:4D, left 2D:4D, and Dr-l), age, and body-size variables (height, mass, BMI, mean digit length for right hand and mean digit length for left hand). Values of *r* were calculated for the total sample (which included Caucasian and Black participants (*n* = 28) and Caucasians only (*n* = 25) (see Table 1 for values of *r* and *p*). The Caucasian only correlations were calculated to facilitate comparisons with the previously reported data for men [3]. For speeds 6 km/h to 12 Km/h, the samples comprised n = 28 for the former and n = 25 for the latter; for speed 14 km/h, they comprised n = 26 for the former and n = 23 for the latter.

***Table 1 is near to here***

Regarding digit ratios: generally, there were positive correlations with lactate levels; most were not significant, but some reached their strongest value at 14 km/hr speed. At this speed for the total sample, right 2D:4D showed a large positive association with lactate ($r$ = .633, $p$ = .0005: Figure 2) and left 2D:4D, a moderate positive association ($r$ = .471, $p$ = .02). For the Caucasian sample, there was a moderate positive association for right 2D:4D ($r$ = .439, $p$ = .04) and a small positive association for left 2D:4D ($r$ = .274, $p$ = .21). The Dr-l was not significantly related to lactate at any speed.

Considering age, there were three negative medium to large negative correlations with lactate at speeds 8 km/hr, 10 km/hr, and 12 km/hr for both samples, with values ranging from $r$ = -. 404 to $r$ =- .567 and $p$ values ranging from .02 to .003. However, at a speed of 14 km/hr, there were no significant correlations between age and lactate.

The "linear" body size variables (height, mean length of right digits, mean length of left digits) showed many negative correlations with lactate such that for height, there were moderate to large negative correlations with lactate for the total sample, and for Caucasians at every speed. At 14 km/hr there were large negative correlations for the total sample ($r$ = -.512, $p$ = .008) and the Caucasian sample ($r$ = -.522, $p$ = .01). Considering mean digit lengths, the magnitude of the correlations was less than those for height. However, there were moderate-sized negative correlations at 12 km/hr for the total sample (mean right digits $r$ = -.438, $p$ = .02 and mean left digits $r$ = -.445, $p$ = .02). At 14 km/hr the correlations were moderate to large in magnitude (total, mean right $r$ = -.614, $p$ = .0008; mean left $r$ = -.681, $p$ = <.0001: Caucasians, mean right $r$ = -.465, $p$ = .03; mean left $r$ = -.599, $p$ = .003).

The remaining "non-linear" body size variables, i.e., mass and BMI, showed small to moderate correlations with lactate for both total and Caucasian samples. With regard to mass, the associations were negative in direction, with few significant relationships and none at 14 km/hr. Concerning BMI, all correlations with lactate were positive and small, with no significant relationships at any speed.

*Multiple regression analyses*

We have nine variables that were related, with varying strengths, to lactate concentrations at different running speeds. Focussing on the fastest speed (14 km/hr), positive correlations existed between digit ratio (both right 2D:4D and left 2D:4D) and lactate. Linear body traits (height, right and left-hand digit lengths) were negatively related to lactate. The Black participants had lower 2D:4D and lower lactate levels than the Caucasians. We removed the former and considered Caucasians only ($n$ = 23 at 14 km/hr) and performed two multiple regression analyses (dependent variable lactate at 14 km/hr and independent variables right or left 2D:4D, height, and mean digit lengths for right or left hands). Concerning the right-hand analysis, 2D:4D remained positively and significantly related to lactate ($r$ = .633 to standardised coefficient $b$ = .416, $p$ = .028), height was negatively associated with lactate but not significant ($r$ = -.512 to $b$ = -.496, $p$ = .055), and mean digit length was negatively but non-significantly related to lactate ($r$ = -.614 to $b$ = .195, $p$<.05). The left-hand analysis showed similar patterns but no significant associations (Table 2).

***Table 2 is near to here***

**Discussion**

Our total sample was 28 female professional football players. Running speeds varied from 6km/h up to 14 km/h, and the participants showed an increase in mean blood lactate values across this range. The ethnic make-up of the sample was 25 Caucasian and 3 Black participants. The former had higher mean lactate concentrations at running speeds of 12 and 14 km/h and higher right and left 2D:4D than the latter. No relationships existed between 2D:4D and lactate for speeds 6 to 12 km/h. However, at the highest running speed (14 km/hr), digit ratios were positively related to lactate level in the total sample and Caucasian only-sample, with the strongest relationships for right 2D:4D (large) compared to left 2D:4D (medium). Of the remaining variables, there were several negative relationships, including the “linear” body size variables (height, mean length of right digits, mean length of left digits), with height being the most consistent correlate. Multiple regressions across all five speeds (independent variables right 2D:4D, height, mass, right digit length, ethnicity) showed that lactate was positively related to right 2D:4D at the highest running speed and height was negatively related across all speeds.

Female and male relationships between digit ratio and lactate during cardiopulmonary tests are similar [3]. Regarding ethnicity, Black participants had lower 2D:4D and lactate levels than Caucasian subjects. Focussing on the largest ethnic group in our sample, i.e. Caucasians, we found a tendency for positive correlations between digit ratios (right, left and Dr-l) and lactate for women and men. However, the latter showed stronger correlations at each running speed. Concerning men, five running speeds varied from 8 km/hr to 16 km/hr. Right 2D:4D was positively correlated with running speed with values of $r$ varying from .616 to .789, left 2D:4D varied from .416 to .567, and Dr-l from .217 to .318. At the highest running speed (16 km/hr), $r$ values were, right 2D:4D $r$ = .780, left 2D:4D $r$ = .525, and Dr-l $r$ = .327. The five running speeds for women varied from 6 km/hr to 14 km/hr. Values of $r$ for right 2D:4D varied from .065 to .439, left 2D:4D from -.096 to .274, Dr-l from -.014 to .304. The most substantial relationships were found at 14 km/hr (right $r$ = .439, left $r$ = .274, Dr-l $r$ = .096). Testosterone levels were not measured in either the male or female study. It is possible that acute spikes of testosterone during exercise had a moderating effect on sex differences in the digit ratio and lactate relationship.

Notably, right 2D:4D is more strongly related to lactate than left 2D:4D at all running speeds. This pattern of stronger effects for right 2D:4D relationships with target traits was first reported for 2D:4D correlations with sperm parameters [7]. It has been suggested that in sexually dimorphic traits in general, and in the 2D:4D, there is a tendency for the "male form" to be expressed more strongly on the right side of the body [26]. Thus, right minus left 2D:4D (Dr-l) is sexually dimorphic in a similar pattern to that of right or left 2D:4D (males<females) [9]. Regarding the ontogeny of the sex difference in 2D:4D, Zheng and Cohn (2011) [27] have reported that the sexual dimorphism in 2D:4D appears first in the right paw of mice. It may be that one explanation for these lateralized patterns of 2D:4D is that receptors for testosterone and oestrogen are more densely expressed in the foetal digits of the right hand. However, to our knowledge, there is currently no empirical evidence supporting this hypothesis.

We have found that 2D:4D is positively related to blood lactate during aerobic exercise in women. However, the association in women is not as strong as that reported in a comparable group of men. Considering morphometric variables, negative correlations between linear body dimensions and lactate were found in females, but not in males. In this regard, height was the most important variable in females across all running speeds, and high blood lactate was found in short participants. The 2D:4D and height are sexually dimorphic (2D:4D males<females: height males>females) and they are thought to be biomarkers for the action of sex steroids at different points in the life cycle. The former is established in the first trimester and the latter during puberty. The 2D:4D is a negative correlate of testosterone and a positive correlate of oestrogen. Mice models have shown receptors for testosterone and oestrogen are present on the foetal 2$^{nd}$ and 4$^{th}$ digits with greater density on the latter [27]. Male foetuses secrete testosterone from their testes. Thus, they experience higher testosterone relative to oestrogen than female foetuses. Foetal testosterone stimulates skeletogenic genes and foetal oestrogen down-regulates these genes. In comparison to females, the 4$^{th}$ digit in male foetuses is longer and 2D:4D is lower. We have found high 2D:4D is associated with high levels of lactate during exercise. This indicates that during aerobic exercise high prenatal oestrogen is linked to lactate production. Height is also a biomarker for sex steroids but in this case, it is oestrogen, through effects on growth hormone (GH) secretion, which stimulates longitudinal growth in both girls and boys [28]. Oestrogen has a biphasic action on longitudinal growth, low levels of oestrogens, as in boys and some girls, stimulates bone growth through effects on GH. Conversely, higher levels of oestrogens (as in most girls) stimulate epiphyseal fusion. A negative correlation between height and lactate production indicates a link between high pubertal oestrogen and the latter [29]. Therefore, we suggest that high prenatal oestrogen (as indicated by high 2D:4D) and high pubertal oestrogen (as indicated by low longitudinal growth) are both correlates of high lactate production during aerobic exercise in women.

There are several limitations in this study. (i) The small sample size, particularly with only three Black participants, limits the generalizability of the findings across diverse populations. (ii) The cross-sectional design prevents the establishment of causal relationships between the 2D:4D ratio and lactate levels. (iii) Variations in individual years of experience or training age, training regimens, nutrition, and recovery were not controlled, potentially influencing lactate measurements. (iv) The reliance on hand scans and lactate testing methods could introduce minor inaccuracies. Future studies should use larger, more diverse samples for greater generalizability and include goalkeepers and players from various competition levels.

Longitudinal designs could help clarify causal relationships, while controlling for factors like diet, recovery, and stress would improve accuracy.

In conclusion, lactate is a crucial exerkine that is produced during vigorous exercise. The essential point here is that lactate is produced during periods of stress when levels of ATP may be low [2]. Lactate and digit ratio share links with sports performance, developmental disorders (such as autism and ADHD), cardiovascular function and many cancers [3]. We have found that 2D:4D is positively related to blood lactate during vigorous exercise in women. However, the association is not as strong as that reported in a comparable group of men. This may be because the positive association between 2D:4D and lactate is dependent on oestrogen. In men the link between oestrogen and lactate can be seen in the prenatal biomarker of 2D:4D. In women it is expressed in 2D:4D but the association with lactate across running speeds is more strongly seen in the pubertal biomarker of height. Thus, in women, height is associated with lactate because female oestrogen levels during puberty are higher than those for men.**References**

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Figure 1

Mean (SE) blood lactate concentrations (mmol/l) at treadmill speeds; 6km/h, 8 km/h, 10 km/h, 12 km/h and 14 km/h in $n$ = 26 female football players.

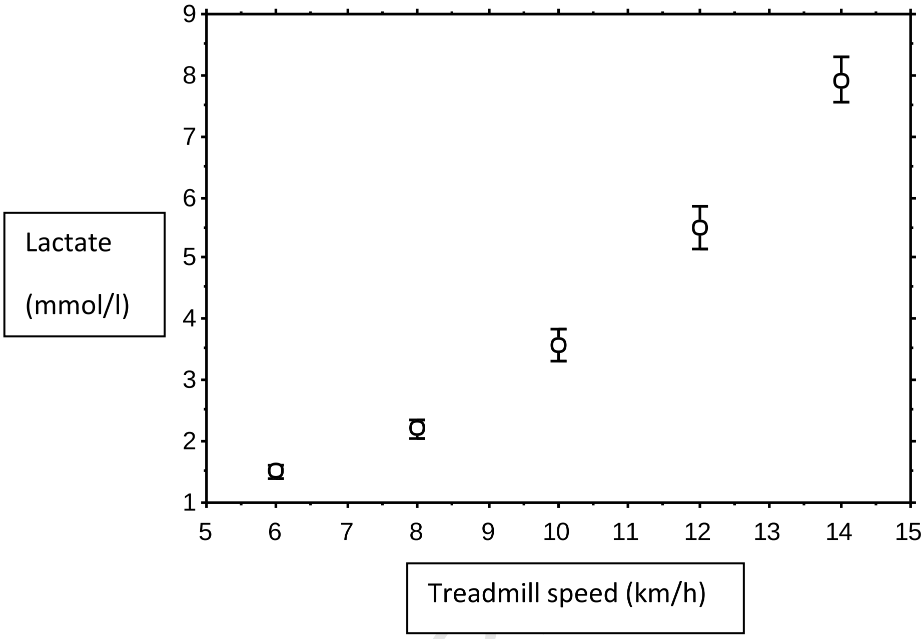
Lactate
(mmol/l)
Treadmill speed (km/h)
1
2
3
4
5
6
7
8
9
5
6
7
8
9
10
11
12
13
14
15

Figure 2

The relationship at 14 km/hr treadmill speed in $n$ = 26 female footballers between (A) right 2D:4D and blood lactate concentration and (B) height and blood lactate concentration. The equation for the regression line of (A) is: y = 40.851x – 31.299, $r^2$ = .399, and of (B): y = -.188x + 38.765, $r^2$ = .262.

Height (cm)

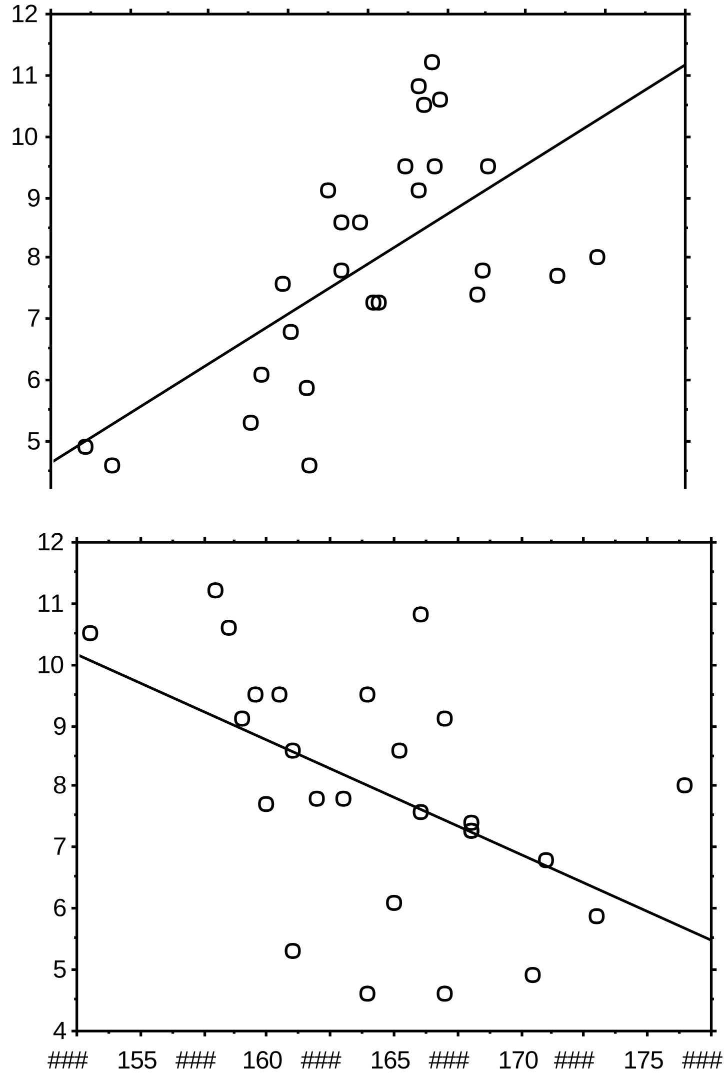

Table 1

Relationships (product-moment correlations, *r*) in female football players between digit ratios (right and left 2D:4D and Dr-l), age, height, mass, BMI, mean length of right digits, mean length of left digits and blood lactate concentrations (mmol/l) at five running speeds.

| Variables | | 6 km/h | 8 km/h | 10 km/h | 12 km/h | 14 km/h |
|---|---|---|---|---|---|---|
| *R2D:4D* | All | .314 (.10) | .327 (.09) | .232 (.24) | .355 (.06) | **.633** (.0005) |
| | Caucasians | .176 (.40) | .145 (.49) | .065 (.76) | .187 (.37) | **.439** (.04) |
| *L2D:4D* | All | .159 (.42) | .221 (.26) | .210 (.28) | .10 (.61) | **.471** (.02) |
| | Caucasians | .02 (.93) | .060 (.77) | .079(.71) | -.096 (.65) | . 274 (.21) |
| *Right-Left 2D:4D Dr-l* | All | .204 (.30) | .154 (.44) | .034 (.87) | .324 (.09) | .169 (41) |
| | Caucasians | .166 (.43) | .103(.62) | -.014 (.95) | .304 (.14) | .096 (.66) |
| *Age* | All | -.316 (.10) | **-.490** (.008) | **-.504** (.006) | **-.404** (.02) | .170 (.41) |
| | Caucasians | -.364 (.07) | **-.567** (.003) | **-.561** (.004) | **-.514** (.009) | .137 (.53) |
| *Height* | All | **-.516** (.005) | **-.477** (.01) | **-.574** (.001) | **-.654** (.0002) | **-.512** (.008) |
| | Caucasians | **-.486** (.02) | **-.442** (.03) | **-.556** (.004) | **-.648**(.0005) | **-.522** (.014) |
| *Body Mass* | All | -.283 (.14) | -.281 (.15) | -.275 (.16) | **-.395** (.04) | -.190 (.35) |
| | Caucasians | -.303 (.14) | -.311 (.13) | -.307 (.14) | **-.457** (.02) | -.283 (.19) |
| *BMI* | All | .246 (.21) | .076 (.71) | .159 (.42) | .261 (.18) | .244 (.23) |
| | Caucasians | .224 (.28) | .023 (.91) | .117 (.58) | .221 (.29) | .208 (.34) |
| *Mean Right Digits* | All | -.182 (.35) | -.182 (.35) | -.294 (.13) | **-.438** (.02) | **-.614** (.0008) |
| | Caucasians | -.04 (.85) | -.002 (.99) | -.167 (.42) | -.306 (.14) | **-.465** (.03) |
| *Mean Left Digits* | All | -.311 (.11) | -.289 (.14) | -.362 (.06) | **-.445** (.02) | **-.681** (<.0001) |
| | Caucasians | -.212 (.31) | -.156 (.46) | -.262 (.21) | -.330 (.11) | **-.599** (.003) |

This table's **bolded values** represent statistically significant results, as indicated by *p*-values below 0.05.

Table 2

Five multiple regression analyses with dependent variable blood lactate level (mmol/l).

| Speed | Trait | Coefficient | St. Error | St. Coefficient | *t* | *p* |
|---|---|---|---|---|---|---|
| *6 km/h* *n* = 28 | Right 2D:4D | 2.213 | 3.695 | .132 | .599 | .56 |
| | Height | -.066 | .025 | -.694 | -2.597 | **.02** |
| | Mass | .008 | .020 | .107 | .412 | .68 |
| | Mean R. digits | .050 | .035 | .329 | 1.322 | .17 |
| | Ethnicity | -.384 | .399 | -.235 | -.962 | .35 |
| *8 km/h* *n* = 28 | Right 2D:4D | 2.300 | 6.469 | .079 | .356 | .73 |
| | Height | -.097 | .045 | -.583 | -2.170 | **.04** |
| | Mass | .001 | .034 | .006 | .023 | .98 |
| | Mean R. digits | .094 | .062 | .354 | 1.523 | .14 |
| | Ethnicity | -1.050 | .699 | -.369 | -1.502 | .15 |
| *10 km/r* *n* = 28 | Right 2D:4D | -.248 | 9.689 | -.006 | -.026 | .98 |
| | Height | -.195 | .067 | -.764 | -2.921 | **.008** |
| | Mass | .041 | .052 | .200 | .789 | .44 |
| | Mean R. digits | .069 | .093 | .169 | .747 | .46 |
| | Ethnicity | -1.046 | 1.047 | -.238 | -.999 | .33 |
| *12 km/h* *n* = 28 | Right 2D:4D | 4.765 | 11.557 | .082 | .412 | .68 |
| | Height | -.224 | .080 | -.675 | -2.813 | **.01** |
| | Mass | .024 | .062 | .090 | .389 | .70 |
| | Mean R. digits | .023 | .111 | .043 | .208 | .84 |
| | Ethnicity | -1.254 | 1.249 | -.220 | -1.004 | .33 |
| *14 km/h* *n* = 26 | Right 2D:4D | 26.949 | 10.979 | .416 | 2.455 | **.02** |
| | Height | -.182 | .075 | -.496 | -2.419 | **.03** |
| | Mass | .087 | .053 | .308 | 1.630 | .12 |
| | Mean R. digits | -.107 | .105 | -.195 | -1.023 | .32 |
| | Ethnicity | -.939 | 1.100 | -.159 | -.854 | .40 |

This table's **bolded values** represent statistically significant results, as indicated by *p*-values below 0.05.

Highlights

- Digit ratios and height are prenatal and pubertal sex steroid biomarkers
- In women digit ratios and height are correlates of lactate during exercise.
- The digit ratio correlations are positive and strongest for right-hand.
- The height correlations are negative