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SEX DIFFERENCES IN 20 METER SPRINT AND 5 M × 4 SHUTTLE RUN PERFORMANCE AMONG PENCAK SILAT ATHLETES

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Abstract
Linear sprint speed and change-of-direction (COD) speed are physical qualities relevant to the footwork-dependent, intermittent demands of pencak silat, yet sex-specific field data for Indonesian athletes are scarce. This study compared 20-m sprint and 5-m × 4 shuttle-run completion times between male and female pencak silat athletes of IPSI Kutai Kartanegara and examined whether the differences remained after adjustment for chronological age. A cross-sectional comparative design was applied to 43 athletes aged 16–27 years (22 males, 21 females; total sampling). Differences were tested with Welch's t-test and Hedges' g, followed by linear regression with age as a covariate and HC3 robust standard errors. Males were faster than females in the 20-m sprint (3.28 ± 0.53 vs. 3.78 ± 0.34 s; difference = 0.50 s, 95% CI [0.23, 0.78]; g = 1.10) and in the shuttle run (6.35 ± 0.70 vs. 6.89 ± 0.60 s; difference = 0.54 s, 95% CI [0.14, 0.94]; g = 0.81). The age-adjusted differences were 0.51 s (p = 0.002) and 0.54 s (p = 0.011), and both remained significant after Holm correction. Because the absolute gaps were almost identical in the two tests, the shuttle-run difference appears to mirror linear speed rather than an additional sex-specific cost of changing direction (exploratory interpretation). Within this sample, male athletes were faster in both tests independently of age, supporting the use of sex-specific reference values. Training history, anthropometry, maturity, and strength were not measured; therefore, the findings are descriptive and do not establish causes of the difference.

Keywords: *Pencak Silat; Sex Differences; Linear Sprint; Change-Of-Direction Speed; Shuttle Run.*

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INTRODUCTION

Pencak silat is an Indonesian martial art that has developed into a structured, weight-categorised combat sport. In the competitive (tanding) category, a match consists of three 2-minute rounds in which attacks and defences must be initiated through specific step patterns (Aziz et al., 2002). Match-play data from elite

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exponents showed mean heart rates above 84% of estimated maximum and post-round blood lactate concentrations of 6.7–18.7 mmol/L, indicating high aerobic and anaerobic demands, while their explosive leg power exceeded that of taekwondo and judo athletes (Aziz et al., 2002). Reviews of karate and taekwondo likewise portray high-level striking combat sports as dependent on neuromuscular and anaerobic attributes in addition to aerobic fitness (Bridge et al., 2014; Chaabene et al., 2012). Because footwork precedes almost every scoring action, linear sprint speed and change-of-direction (COD) speed are logical qualities to monitor, and Indonesian test batteries for adult competitive pencak silat athletes accordingly include sprint and shuttle-run tests (Kuswanto, 2016).

Linear sprint and COD tests, however, should not be treated as interchangeable. The 20-m sprint measures straight-line acceleration over a short distance, whereas the 5-m × 4 shuttle run requires athletes to decelerate, turn, and re-accelerate within a total distance of 20 m. Linear sprint speed and COD speed are partly independent qualities (Young et al., 2015), and a systematic review of speed tests classified linear sprint and COD tests as different measurement categories (Altmann et al., 2019). COD performance is further related to approach and exit velocity, braking and propulsive forces, and joint and trunk mechanics (Dos'Santos et al., 2018a, 2021; Singh et al., 2025). In addition, a pre-planned shuttle run contains no perceptual-decision component, which distinguishes it from reactive agility (Paul et al., 2016; Sheppard & Young, 2006). In this study, the 5-m × 4 shuttle run is therefore interpreted strictly as a measure of pre-planned COD speed.

Sex is a major source of between-athlete variation in these qualities. After puberty, higher testosterone concentrations in males are associated with greater muscle mass and strength (Handelsman et al., 2018; Hunter et al., 2023), alongside sex differences in muscle fibre size and composition (Haizlip et al., 2015; Miller et al., 1993; Nuzzo, 2023, 2024). In running events, the performance gap between male and female athletes widens from below 5% at age 11 to 10–18% by age 18

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(Tønnessen et al., 2015) and remains on the order of 10% among elite adults (Cheuvront et al., 2005; Millard-Stafford et al., 2018; Sandbakk et al., 2018; Thibault et al., 2010). Part of the gap may reflect strength relative to body mass rather than sex itself, because rapid force production no longer differed between strength-matched females and males (Comfort et al., 2024). Since muscular strength underpins both sprinting and COD ability (Brughelli et al., 2008; Chaabene et al., 2018; Spiteri et al., 2014; Suchomel et al., 2016), sex differences are expected in both tests, although their relative size may differ (Dos'Santos et al., 2018b; Freitas et al., 2022).

Evidence from pencak silat itself is limited. Studies that combine sprint and agility testing concentrate on youth athletes: Sari and Sumartiningsih (2025a) related peak height velocity to 20-m sprint and Illinois Agility Test performance in athletes aged 11–15 years, and a related study (Sari & Sumartiningsih, 2025b) of 20 athletes in the same age range reported faster agility in males but no significant sex difference in sprint time ($p = 0.064$). Physiological profiling of elite exponents of both sexes (Aziz et al., 2002) did not include field sprint or COD tests. It therefore remains unclear whether sprint and pre-planned COD performance differ between male and female pencak silat athletes in the late-adolescent and adult range, and whether the differences are of comparable size. The question also matters because female athletes remain under-represented in sport-science research (Cowley et al., 2021; Nimphius, 2019), which limits the sex-specific reference data available to coaches.

A further practical issue is that male and female athletes in a regional association often differ in age and, by extension, in training age and maturity, which can confound a simple comparison (Lloyd et al., 2015). In the present cohort the age distribution differed between the sexes (see Results), which motivated adjustment for age. This study therefore compared 20-m sprint and 5-m × 4 shuttle-run completion times between male and female pencak silat athletes of IPSI Kutai Kartanegara and examined whether the differences remained after age adjustment.

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We hypothesised that male athletes would be faster in both tests (H1) and that the differences would persist after age adjustment (H2). We also explored, descriptively, whether the sex difference was proportionally similar in the linear sprint and the shuttle run, as an indication of how much of the difference is expressed when direction changes are added to straight-line running.

METHOD

Study Design and Participants

This study used a cross-sectional comparative design with sex as the grouping factor. Participants were all 43 pencak silat athletes of IPSI Kutai Kartanegara with complete test records (total sampling), comprising 22 males and 21 females aged 16–27 years. Body mass, height, training experience, and competition category were not recorded in the dataset and could not be analysed.

Outcome Measures

Two field tests were analysed. Both were recorded in seconds, and lower values indicate faster performance. The 20-m sprint measured linear speed from a start position and was timed with timing equipment, e.g., single- or dual-beam timing gates or stopwatch. The 5-m × 4 shuttle run required athletes to cover four 5-m lengths (20 m in total), reversing direction at each end line, and was used as a measure of pre-planned COD speed. Because timing configuration and start position systematically influence recorded sprint times (Haugen & Buchheit, 2016; Haugen et al., 2014; Yeadon et al., 1999). Chronological age (years) was used as a covariate.

Statistical Analysis

Data are presented as mean ± standard deviation (SD). Between-sex differences were tested with Welch's independent-samples *t*-test, which does not assume equal variances (Delacre et al., 2017), and are reported as mean differences (female minus male) with 95% confidence intervals (CIs) and Hedges' *g* (Lakens, 2013). Standardised differences were interpreted with the thresholds of Hopkins et al. (2009): 0.2 (small), 0.6 (moderate), 1.2 (large), and 2.0 (very large). To test

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whether the differences persisted after accounting for age, two separate linear regression models were fitted (one per outcome), with sex (male = reference) and age as predictors and HC3 heteroscedasticity-consistent standard errors, which perform better than conventional estimators in small samples (Long & Ervin, 2000). Because two outcomes were tested, Holm-adjusted *p*-values are reported alongside unadjusted values (Holm, 1979); the significance level was 0.05.

Because the sample comprised all available athletes, no *a priori* power analysis was performed. A sensitivity analysis showed that, with 22 versus 21 athletes, a two-sided α of 0.05, and 80% power, only standardised differences of $d \approx 0.88$ or larger could be detected reliably. Hedges' *g*, relative differences (percentage of the male mean), and the sensitivity analysis were calculated from group means and SDs. Data screening covered completeness, internal consistency, and verification of extreme values against source records; extreme values were not removed on the basis of their magnitude alone. Analyses were performed with SPSS 30.

Ethical Considerations

Data were anonymised before analysis, and no direct participant identifiers are reported.

RESULT AND DISCUSSION

Forty-three athletes (22 males, 21 females) were analysed. Male athletes were older than female athletes (21.00 ± 3.06 vs. 18.29 ± 2.39 years; difference = −2.71 years, 95% CI [−4.40, −1.02]; Welch $p = 0.002$), which supported the planned adjustment for age. Male athletes recorded shorter completion times in both tests (Table 1).

Table 1. Participant characteristics and unadjusted between-sex comparisons

Variable	Male (*n* = 22)	Female (*n* = 21)	Difference, female − male [95% CI]	*p*
Age (years)	21.00 ± 3.06	18.29 ± 2.39	−2.71 [−4.40, −1.02]	0.002
20-m sprint (s)	3.28 ± 0.53	3.78 ± 0.34	0.50 [0.23, 0.78]	0.001
5-m × 4 shuttle run (s)	6.35 ± 0.70	6.89 ± 0.60	0.54 [0.14, 0.94]	0.009

Note. Data are mean ± SD. Differences and 95% CIs are from Welch's t-test. Lower times indicate faster performance.

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In the 20-m sprint, female athletes were on average 0.50 s slower than male athletes (95% CI [0.23, 0.78]; $p = 0.001$; $g = 1.10$, 95% CI [0.46, 1.74]), a relative difference of 15.2% of the male mean. In the 5-m × 4 shuttle run, the difference was 0.54 s (95% CI [0.14, 0.94]; $p = 0.009$; $g = 0.81$, 95% CI [0.19, 1.43]), or 8.5% of the male mean. Both standardised differences were moderate according to Hopkins et al. (2009). The SD of male sprint times (0.53 s) was about 1.6 times that of female athletes (0.34 s).

After adjustment for age, the estimated difference was 0.51 s in the sprint (95% CI [0.18, 0.83]; $p = 0.002$) and 0.54 s in the shuttle run (95% CI [0.12, 0.96]; $p = 0.011$) (Table 2). These estimates were almost identical to the unadjusted differences (0.50 and 0.54 s), age was not significantly associated with either outcome, and both differences remained significant after Holm correction (adjusted $p = 0.004$ and 0.011). The age imbalance between the groups therefore did not explain the sex differences in this sample.

Table 2. Effect sizes and age-adjusted between-sex differences

Outcome	Hedges' *g* [95% CI]	Relative difference (%)	Age-adjusted difference, s [95% CI]	*p*	Holm *p*
20-m sprint	1.10 [0.46, 1.74]	15.2	0.51 [0.18, 0.83]	0.002	0.004
5-m × 4 shuttle run	0.81 [0.19, 1.43]	8.5	0.54 [0.12, 0.96]	0.011	0.011

Note. Differences are female minus male (male = reference). Models were linear regressions including sex and age with HC3 standard errors. Hedges' g and relative differences (percentage of the male mean) were calculated from group means and SDs. Holm adjustment was applied across the two outcomes.

Because both tests cover a total distance of 20 m, the difference between shuttle-run time and sprint time can be used as an approximation of the COD deficit (Nimphius et al., 2016), that is, the time cost attributable to decelerating, turning, and re-accelerating. Computed from group means, this cost was 3.07 s in male athletes (6.35 − 3.28) and 3.11 s in female athletes (6.89 − 3.78), a mean difference of only 0.04 s.

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Discussion

Male athletes were faster than female athletes in the 20-m sprint (0.50 s; g = 1.10) and in the 5-m × 4 shuttle run (0.54 s; g = 0.81), and neither difference was attenuated after adjustment for age. The results therefore support both hypotheses (H1 and H2). Because the unadjusted and age-adjusted estimates were virtually identical (0.50 vs. 0.51 s and 0.54 vs. 0.54 s), the 2.7-year age imbalance does not appear to account for the sex difference in this cohort. Chronological age is, however, only a coarse proxy for maturity and training history (Lloyd et al., 2015), so the adjustment narrows but does not eliminate the possibility of confounding.

Female athletes were 15.2% slower than male athletes in the 20-m sprint. This is somewhat larger than the gap of roughly 10% reported for elite adult runners (Cheuvront et al., 2005; Millard-Stafford et al., 2018; Sandbakk et al., 2018; Thibault et al., 2010) but lies within the 10–18% range that emerges by age 18 in competitive running events (Tønnessen et al., 2015), which is plausible for a cohort aged 16–27 years. The physiological candidates identified in the literature, namely androgen-driven differences in muscle mass, strength, and fibre characteristics (Haizlip et al., 2015; Handelsman et al., 2018; Hunter et al., 2023; Miller et al., 1993; Nuzzo, 2023, 2024), were not measured here and cannot be tested with these data. The finding that rapid force production is similar in strength-matched females and males (Comfort et al., 2024) suggests that strength relative to body mass is a priority variable for future work.

A contrast with youth pencak silat athletes is instructive. Sari and Sumartiningsih (2025b) found no significant sex difference in sprint time at 11–15 years (p = 0.064), whereas the present 16–27-year sample shows a clear difference. This is in line with a gap that widens after puberty (Tønnessen et al., 2015), but the studies differ in age, sample size (n = 20 vs. 43), and tests, so the comparison is suggestive only. Two measurement issues also deserve attention. First, absolute sprint times depend on the timing system and start position (Haugen et al., 2014; Yeadon et al., 1999), which limits comparison of absolute values with other studies,

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whereas a sex comparison under one protocol is less affected (Haugen & Buchheit, 2016). Second, the SD of male sprint times (0.53 s) was about 1.6 times that of female athletes, which may reflect heterogeneity in training status among the male athletes or measurement noise; Welch's test and HC3 standard errors accommodate unequal variances, but the wide CIs should be read with this heterogeneity in mind.

In the shuttle run, female athletes were 0.54 s (8.5%) slower, a smaller proportional difference than in the sprint (15.2%). The CIs of the two standardised differences overlap, so the data do not permit a formal claim that the sex effect differs between tests. Nevertheless, the exploratory COD-deficit approximation sheds light on the pattern: the absolute gap was almost the same in both tests (0.50 vs. 0.54 s), and the extra time cost of the shuttle run relative to the sprint was nearly equal in males and females (3.07 vs. 3.11 s). Taken together, these descriptive values suggest that the sex difference in the shuttle run largely mirrors the difference in linear speed rather than an additional sex-specific cost of turning. This reading is consistent with the idea that the COD deficit isolates COD ability from linear speed better than total test time does (Dos'Santos et al., 2018b; Nimphius et al., 2016), and it explains why the relative difference is smaller in the shuttle run: a time cost of about 3 s shared by both sexes dilutes the proportional gap.

This interpretation is provisional. The deficit was computed from group means and has no individual-level variance, and the COD cost of a 5-m shuttle depends on approach velocity, turning angle, braking capacity, and technique (Dos'Santos et al., 2018a, 2021; Singh et al., 2025). Lower-limb strength, particularly eccentric strength, contributes to braking and re-acceleration (Brughelli et al., 2008; Chaabene et al., 2018; Spiteri et al., 2014; Suchomel et al., 2016), but none of these determinants was measured. In addition, a pre-planned shuttle run does not capture the perceptual-decision component of reactive agility (Paul et al., 2016; Sheppard & Young, 2006; Young et al., 2015), which is central to responding to an opponent in pencak silat. Sprint and COD qualities also differ across sports

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even within female athletes (Freitas et al., 2022), which supports the development of sport-specific reference values rather than borrowing norms from other sports.

Match demands appear comparable between the sexes: male and female exponents in a previous study worked at similar proportions of maximal heart rate with similar blood lactate responses (Aziz et al., 2002). A lower absolute speed in female athletes therefore does not imply a lower relative match demand, and the present results support sex-specific reference values when using sprint and shuttle-run tests such as those in Kuswanto's (2016) battery. Group differences should not be used as individual standards; coaches should track each athlete's change over time, report sprint and shuttle-run results separately, and, where data allow, compute the COD deficit. Complementing pre-planned tests with tasks that require responding to a visual cue or an opponent would bring the evaluation closer to match conditions. This is a recommendation for future monitoring, not a conclusion drawn from the present data, which contain no training intervention.

Several limitations apply. First, the cross-sectional design prevents causal inference, and the findings describe differences between groups, not the effect of sex itself. Second, the sample was small and came from one regional association; the sensitivity analysis shows that only differences of about $d \approx 0.88$ or larger could be detected reliably, so the CIs of the adjusted estimates are wide. Third, training experience, competition category, anthropometry, maturity, and strength were not available, so residual confounding by these factors cannot be excluded. Fourth, the menstrual cycle phase of female athletes was not recorded; although its effect on exercise performance appears trivial and variable, the evidence quality is low (McNulty et al., 2020), and methodological guidance recommends documenting menstrual status in studies of women (Elliott-Sale et al., 2021). Fifth, the exploratory COD-deficit analysis rests on group means. Finally, the shuttle run measures pre-planned COD speed only.

Future studies should recruit male and female athletes from several regions and competition levels, record training age, anthropometry, maturity status, and

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relative strength, use standardised and reliable timing procedures, analyse individual-level COD deficit with confidence intervals, and add reactive agility tests. Longitudinal or intervention designs are needed if the aim is to examine the development of performance or the effect of training programmes.

CONCLUSION

Male pencak silat athletes of IPSI Kutai Kartanegara completed the 20-m sprint and the 5-m × 4 shuttle run faster than female athletes, with age-adjusted differences of 0.51 s (g = 1.10) and 0.54 s (g = 0.81), respectively. The age imbalance between the groups did not explain these differences. Because the absolute gaps were nearly equal in both tests, the shuttle-run difference appears to mirror linear speed rather than an additional sex-specific cost of changing direction, an exploratory interpretation that requires individual-level confirmation. The results support sex-specific reference values for monitoring sprint and pre-planned COD speed in this athlete population. As training history, anthropometry, maturity, and strength were not measured and the design was cross-sectional, the findings should not be taken as evidence that biological sex alone causes the observed differences. Future research should include more diverse samples and these additional variables.

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