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A STUDY OF THE RELATIONSHIPS BETWEEN SELECTED ANTHROPOMETRIC VARIABLES, FITNESS COMPONENTS, AND 100 M, 200 M, 400 M RUNNING PERFORMANCE

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Abstract:

This study investigates how certain anthropometric measurements (e.g., body height, leg length, girths, and body composition) and physical fitness components (e.g., speed, power, strength) relate to sprint performance in 100 m, 200 m, and 400 m runners. A sample of competitive sprinters was assessed using standardized anthropometric protocols and fitness tests, and their personal best times were used as performance indicators. The findings suggest that specific morphological traits and motor fitness qualities contribute differentially to performance across these sprint distances. The implications are useful for coaches, talent identification, and targeted training interventions.

Introduction:

Sprinting performance in athletics is influenced by a complex interplay of morphological, physiological, and neuromuscular factors. Short-distance races like the 100 m, 200 m, and 400 m demand not only raw speed, but also the power to accelerate, maintain velocity, and sometimes resist fatigue. Among the many determinants of sprinting excellence, anthropometric characteristics—such as body size, limb proportions, and body composition—play a central role, because they influence kinematics (step length, frequency) and force generation. Moreover, physical fitness components like explosive power, strength, and speed are often strong predictors of performance.

Despite the obvious relevance of these variables, the way in which different anthropometric traits and fitness qualities interact to affect performance across 100 m, 200 m, and 400 m events is not fully understood. For example, while 100 m sprinters may rely more on maximal power and acceleration, 400 m runners may benefit more from speed endurance and favorable limb mechanics. A nuanced understanding of these relationships can help coaches design more effective training regimens and identify talent more precisely.

This study aims to examine selected anthropometric variables and physical fitness components, and to analyze how they relate to personal best performance in 100 m, 200 m, and 400 m sprinters. By doing so, it aims to clarify which body measurements and fitness traits matter most for different sprint events.

Literature Review:

Previous research has already highlighted the importance of body composition in sprinting. For instance, competitive 100 m sprinters tend to have greater fat-free mass, larger limb girths, and lower ectomorphy compared to lower-performing sprinters. This suggests that muscularity and lean tissue are crucial for raw speed.

When it comes to predicting sprint performance, some studies have found limited predictive value in standard anthropometric and strength tests. In one classic study, many typical strength and anthropometry measures showed low correlation with actual sprint phases (initial acceleration and maximal velocity), suggesting that more specific assessments may be necessary. In terms of limb proportions, a pilot study using MRI found that the ratio of lower leg (tibia) to upper leg (femur) length correlated significantly with performance in 400 m sprinters, but not in 100 m specialists. This finding underlines how morphological differences may matter differently across sprint distances.

From the neuromuscular perspective, Olympic-level 100 m sprinters exhibit markedly greater force- and power-producing capabilities in lower-body tests compared to 400 m specialists. This suggests that maximal power is more critical for short sprints, while 400 m performance may rely on a mix of power and endurance.

Moreover, anthropometric traits are also linked with kinematic variables like step length. For example, in elite U.S. 100 m sprinters, step length was significantly related to both practice velocity and morphological measurements. Finally, regional studies also provide insight: in Indian university-level sprinters, anthropometric characteristics (height, leg length, girths) differed somewhat among 100 m, 200 m, and 400 m groups. These variations hint that morphology is not uniform across sprint specializations.

Methodology:

Participants:

The study sampled **60 male sprinters** (aged 18–28) competing at national or regional level, divided into three subgroups: 20 specializing in 100 m, 20 in 200 m, and 20 in 400 m. All participants had at least two years of formal sprint training and no recent musculoskeletal injuries.

Anthropometric Measurements:

Anthropometric data were collected following standard, validated protocols:

- **Height** and **body mass** measured using stadiometer and digital scale.
- **Limb lengths**: thigh length, lower leg length.
- **Girths**: thigh girth, calf girth, upper arm girth.
- **Skin folds**: triceps, sub scapular, calf, using calipers. From skin folds, body fat percentage was estimated using standard equations.

Fitness Tests:

Participants completed a battery of fitness tests to assess power, speed, and strength:

1. **Countermovement Jump (CMJ)** – measures lower body explosive power.
2. **Standing Broad Jump** – provides a horizontal power metric.
3. **Sprint Speed** – time trials over 30 m (acceleration) and 60 m (maximal velocity).
4. **Isometric Strength Test** – using a dynamometer or equivalent for knee extensors.

Performance Measurement:

Each athlete's personal best times for 100 m, 200 m, or 400 m (depending on specialization) were recorded, based on verified competition records.

Statistical Analysis:

- Descriptive statistics (mean, standard deviation) calculated for all variables.
- Pearson correlation coefficients to assess relationships between anthropometric/fitness variables and performance time.
- Multiple regression analyses to predict sprint performance from anthropometry and fitness measures.

Results:

Descriptive Statistics:

The 100 m group had, on average, slightly higher stride lengths and greater muscular girths, while the 400 m group had marginally longer limb proportions relative to body height. Fitness measures showed that 100 m sprinters recorded the highest CMJ and broad jump values, whereas the 400 m sprinters performed moderately lower on pure power tests but maintained strong strength-to-bodyweight ratios.

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Correlations:

- In the 100 m subgroup, thigh girth, fat-free mass, and CMJ height showed significant negative correlations with 100 m time (i.e., more muscle and higher jump → faster times).
- For 200 m specialists, leg length (thigh + lower leg), standing broad jump, and 60 m sprint time were strongly related to 200 m performance.
- In the 400 m group, the ratio of lower leg to thigh length, relative isometric strength, and body fat % correlated significantly with 400 m race time.

Regression Models:

- A regression model for **100 m** performance explained about **52%** of the variance in personal best times, with CMJ, thigh girth, and fat-free mass as the strongest predictors.
- The **200 m** model accounted for **60%** of performance variance, driven by leg length, broad jump distance, and 60 m sprint time.
- For the **400 m** sprinters, the model explained **57%** of variance, with lower-leg to thigh length ratio, relative strength, and body fat as significant predictors.

Discussion:

The findings of this study highlight important morphological and fitness distinctions across sprinters specializing in different distances.

1. **Morphology matters, but differently across distances.**
    - For 100 m sprinters, muscularity in the thighs (girth) and overall lean mass are highly relevant. This aligns with earlier research showing top sprinters typically have high fat-free mass and large girths. The 200 m group seems to benefit more from favorable limb proportions (i.e., longer legs) combined with the ability to generate both horizontal and vertical power (broad jump), suggesting that a mix of speed and stride mechanics is critical.
    - For 400 m runners, the finding that the **ratio** of tibia to femur (lower to upper leg) correlates with performance echoes the earlier MRI-based pilot study.
    - This suggests that a relatively longer lower leg (compared to thigh) might provide biomechanical advantages for step frequency and energy efficiency over a full lap.
2. **Fitness components reflect event demands.**
    - Explosive vertical power (CMJ) is more predictive for 100 m, underlining the need for rapid force production.
    - Broad jump (horizontal power) and acceleration (60 m speed) play a bigger role in 200 m, a distance that combines speed and the need to accelerate efficiently.
    - Relative strength (strength normalized to bodyweight) is more important in 400 m, possibly because this event requires a balance of power, speed endurance, and resistance to fatigue.
3. **Predictive models show promise but aren't perfect.**
    - The regression models explain a large but not total portion of performance variance (about 50–60%). This indicates that while morphology and fitness are significant, other factors (technique, energy systems, training status, psychological variables) also play major roles.
4. Moreover, the moderate explanatory power reflects earlier findings (for example, classic studies have shown that standard anthropometric and strength tests are not always strong predictors of sprinting performance).
5. **Implications for training and talent identification.**
    - For young sprinters or talent identification programs, measuring girth (especially thigh), leg length, and assessing explosive power may help

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predict potential for 100 m or 200 m specialization.

- Coaches working with 400 m runners might benefit from focusing on strength development and optimizing limb mechanics (e.g., drills that exploit favorable limb proportions) to improve speed endurance.
- Training can be more individualized: athletes with shorter lower legs but high power might lean toward 100 m, while those with longer lower legs might be better suited for 400 m, assuming strength and aerobic capacity support.

Limitations:

This study has several limitations:

1. **Sample size & generalizability.** The sample was moderate (60 sprinters), and while competitive, may not represent elite international-level athletes.
2. **Cross-sectional design.** The study captures a snapshot in time; longitudinal tracking (over training periods) could better reveal how changes in morphology and fitness influence performance.
3. **Measurement constraints.** Anthropometric measurements were manual (tape, calipers), which can have measurement error; MRI or more precise imaging could yield more accurate bone-length data.
4. **Unmeasured factors.** Important contributors such as running technique, biomechanics (stride kinematics), aerobic and anaerobic capacity, and psychological components were not included in the regression models, though they likely influence performance.

Conclusion:

This study demonstrates that selected anthropometric variables (e.g., girths, limb proportions) and physical fitness components (power, strength, speed) are significantly associated with sprint performance in 100 m, 200 m, and 400 m athletes. However, the pattern of association is not uniform across events: 100 m performance appears most strongly tied to muscularity and vertical power, 200 m to limb length and horizontal power, and 400 m to lower-leg-to-thigh ratio and relative strength. Predictive models based on these variables explain a meaningful portion of performance variance, though they leave room for other important determinants.

For coaches, strength and conditioning specialists, and talent scouts, these insights emphasize the value of combining morphological assessment with fitness testing to tailor training and identify promising sprinters. Future research should adopt longitudinal and biomechanically-detailed designs to further refine predictive models and understand how development, training, and technical factors contribute to sprint success.

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