



OPEN Comparison of vertical jump performance between the Maasai, track and field athletes, and non-athletes: a cross-sectional study

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The Maasai are known for their unique customs, including dancing, singing, and jumping. The tribe's traditional jumping rituals, performed by young warriors called 'Morani,' demonstrate their strength and skill through repetitive hops, often lasting several hours. These jumps are comparable to the countermovement jumps (CMJ) of elite Western athletes. This study compared different types of jumps (CMJ), squat jump (SJ) and repetitive hops) among three groups: (a) Maasai ($n=30$), (b) Slovenian high-jump athletes and sprinters ($n=20$), and (c) non-athletes in Slovenia ($n=20$). Participants were male, aged 16–35. The My Jump 2 app was used to measure jump height. Results showed that during CMJ, the Maasai averaged $38.1 \text{ cm} \pm 7.3 \text{ cm}$; athletes $52.46 \text{ cm} \pm 9.07 \text{ cm}$; non-athletes $33.72 \text{ cm} \pm 7.22 \text{ cm}$. In the SJ, the Maasai averaged $35.87 \text{ cm} \pm 6.59 \text{ cm}$; athletes $49.74 \text{ cm} \pm 7.3 \text{ cm}$; non-athletes $32.57 \text{ cm} \pm 6.21 \text{ cm}$. For repetitive hops, the Maasai averaged $36.2 \text{ cm} \pm 7.75 \text{ cm}$; athletes $35.93 \text{ cm} \pm 5.98 \text{ cm}$; non-athletes $20.98 \text{ cm} \pm 7.07 \text{ cm}$. Athletes showed higher jump heights in CMJ and SJ compared to the Maasai ($p < 0.001$, $d = 1.28$; $p < 0.001$, $d = 2.00$) and non-athletes ($p < 0.001$, $d = 2.29$; $p < 0.001$, $d = 2.53$). However, in repetitive hops, the Maasai performed similarly to athletes ($p = 0.991$, $d = 0.04$), while non-athletes had significantly lower results ($p < 0.001$, $d = 2.05$). These findings suggest that the Maasai's cultural practices enhance musculoskeletal adaptation from an early age, emphasizing that proficiency is greatest in regularly practiced tasks, such as repetitive jumps and hops.

Keywords Vertical jumps, Reaction strength index, My jump 2, Maasai

Abbreviations

ANOVA	Analysis of Variance
ASIS	Anterior Superior Iliac Spine
AT	Achilles Tendon
CMJ	Countermovement Jump
COSTECH	Tanzania Commission for Science and Technology
DJ	Drop Jump
GM	Gastrocnemius Muscle
NIMRI	National Institute for Medical Research
RSI	Reactive Strength Index
SD	Standard Deviation
SJ	Squat Jump
SSC	Stretch Shortening Cycle
VL	Vastus Lateralis

The Maasai are pastoralists living a semi-nomadic lifestyle in the East African Rift Valley between Kenya and Tanzania¹. They are particularly known for cultural rituals involving singing, dancing, and repetitive hopping. Young men, known as "Morani", aged approximately 15 to 30 years, are the warriors of the tribe and actively participate in ceremonial jumping². According to oral traditions, Maasai begin imitating jumps in early childhood, and officially engage in them when they become Morani. Children as young as two years attempt to jump, and later, as warriors, they continue participating regularly, not only during ceremonies. This long-

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standing cultural practice represents a central element of their heritage and contributes to their notable jumping ability.

Jumping is a natural, yet complex form of human movement that requires coordination between the upper and lower body^{3,4}. Observations of Maasai repetitive hopping reported jump heights exceeding 50 cm during repetitive hops, which is comparable to the highest countermovement jumps (CMJ) of elite athletes in the Western world^{5,6}. The Maasai's impressive performance may be influenced not only by cultural practice but also by anthropometric traits. Similar to Kenyan runners, who are optimized for economical running and possess longer Achilles tendons and smaller gastrocnemius pennation angles that enable efficient use of elastic energy^{7,8}, the Maasai who regularly perform high vertical jumps in their traditional dances may also develop comparable biomechanical adaptations that enhance elastic energy storage and recoil in the muscle-tendon unit as a result of such habitual loading. Our own observations suggest that they display long Achilles tendon and a favourable shank-to-thigh length ratio, traits that enhance efficiency in the stretch-shortening cycle^{9–11}. Moreover, their relatively low body mass combined with strong legs may further enhance propulsion during jumps¹².

Such physiological and biomechanical characteristics, intertwined with cultural practice, suggest that the Maasai may also demonstrate a high reactive strength index (RSI). RSI is a measure of plyometric capacity defined as the ratio of jump height to ground contact time^{13–15}. RSI reflects the efficiency of eccentric-concentric transition and is recognized tool for assessing neuromuscular function in athletes¹⁶.

In summary, several physiological and biomechanical factors, intertwined with a unique cultural practice, suggest that the Maasai may exhibit distinct jumping capabilities. However, despite these theoretical considerations, there is limited empirical data on their actual jumping performance. The aim of this cross-sectional study is to evaluate the jumping performance of the Maasai using objective measurements to assess various types of jumps, including countermovement jumps (CMJ), squat jumps (SJ), and repetitive hops (15 s repetitive hops test). Given their longstanding engagement in ceremonial jumping from a young age, we hypothesize that the Maasai will demonstrate jumping abilities comparable to athletes, especially in repetitive hops. By comparing jump heights between the Maasai and two groups (athletes and non-athletes) from a Western European environment, we seek to better determine the jumping performance of the Maasai. By bridging the gap between theoretical considerations and empirical evidence, this study provides preliminary insights into the jumping performance of the Maasai, emphasizing the potential role of cultural practices and embodied traditions in shaping biomechanical efficiency.

Methods

Ethical considerations

The study procedures were first approved by the Commission of the University of Primorska for Ethics in Human Subjects Research (approval number: 4264-28-6/23; approved on 12 June 2023). In Tanzania, we obtained institutional ethical approval from the Kilimanjaro Christian Medical University College (Research Ethics Certificate No. 2659; Research Proposal No. 1436; approved on 18 December 2023). National ethical approval was also secured from the National Institute for Medical Research (NIMRI), which is the regulatory body for medical and health research in Tanzania (approval issued on 16 November 2023). Lastly, we obtained research authorization from the Tanzania Commission for Science and Technology (COSTECH). All procedures were conducted in accordance with relevant guidelines and regulations, including the Declaration of Helsinki. Written informed consent was obtained from all participants prior to participation. No identifying information or images are presented in the manuscript.

Participants and study design

We used a cross-sectional study design, utilizing completely non-invasive, short-term, and straightforward measurements. A critical step in the planning phase was selecting the research area in Tanzania. With the assistance of local researchers, we determined that the Maasai predominantly reside on the peripheries of the Kilimanjaro and Arusha regions in the northern part of the country. We also began identifying potential study sites within these regions, specifically in the Monduli District. This area was chosen due to its minimal impact from urbanization, allowing the residents to maintain their traditional practices. Data collection in Tanzania began on 8 February 2024. Participants for the study were recruited with the help of a translator and a local guide, who obtained the contact information of the Maasai elders and leaders. The elders then gathered the participants. Through the translator, we provided a detailed explanation of the research process, after which the participants, along with the translator, signed the informed consent form for participation in the study. In Slovenia, we recruited participants through local athletics clubs (athletes training in high jump and sprinters) as well as through community networks (non-athletes) and data collection in Slovenia began on 4 April 2024.

Our study involved Maasai participants from the Irkisongo clan, predominantly residing in the Monduli area, providing insights specific to this group's practices and lifestyle. The Maasai participants included Morani ($n = 30$), selected based on the inclusion criteria of ages 16–35, which corresponds to this group, as well as athletes ($n = 20$) and non-athletes ($n = 20$). In the athlete group, seven participants were elite athletes from Slovenia, recognized as some of the best performers in the country in 2024. Only three individuals in athlete group were younger than 18 years (one aged 16 and two aged 17). They were included in the study in order to capture a representative range of athletes, given the limited number of available participants. For these minors, participation was supervised and permitted by their coach and informed consent obtained from their parents/legal guardians. The exclusion criteria included any musculoskeletal injuries (current or within the past 6 months), any illness that could be worsened by the measurements, the presence of chronic diseases, and any physical impairments that could interfere with jumping or the execution of jumps.

Assessments

Participant body mass was measured using a calibrated digital scale (KERN MGD 100 K-1, Germany), with participants wearing light clothing. For the purpose of our study, we measured three different types of jumps (CMJ, SJ, and 15-s repetitive hops). SJ and CMJ were performed three times, along with one 15-second trial of repetitive hops. For the Maasai participants, all CMJ trials were completed first, followed by all SJ trials and lastly one 15-second trial of repetitive hops. This sequence was chosen to facilitate their understanding and learning of the testing procedure, as they were encountering these jump types for the first time. In contrast, athletes and non-athletes completed jumping trials in alternating order, with approximately 1–2 min of rest between trials, due to time constraints such as training schedules and work commitments. For these groups, the testing was more familiar and therefore easier to perform compared to the Maasai, for whom the protocol was entirely novel. From the three trials, we selected the best jump based on the jump height. All of the participants performed the jumps barefoot. The Maasai participants performed jumps on a solid wooden board, selected to approximate a hard surface in the absence of athletic tracks in their environment. This choice was made to provide a consistent and functionally comparable surface to that used in standard athletic settings. In contrast, the athletes and non-athletes completed their jumps on a synthetic athletics track, enabling testing under more standardized conditions.

Before starting the jump measurements, we weighed the participants, and conducted introductory measurements to teach the participants the correct jumping technique. Each participant performed 2–3 familiarization jumps for both CMJ and SJ to ensure proper understanding of the tasks. These practice jumps were not included in the final analysis. For the Maasai participants, additional explanations were provided to facilitate learning, as this type of testing was novel to them. The jumps were recorded using a smartphone (iPhone 11) through the My Jump 2 app, with jumping tasks captured at 240 frames per second. My Jump 2 app has been continuously shown to exhibit good to excellent reliability and validity compared to gold standard methods^{17,18}.

Using the My Jump 2 application, we obtained the following indices: jump height, velocity, flight time, force, power, contact time, and % fatigue (for the repetitive hops test). Based on the provided data, we calculated the RSI. However, we focused only on jump height, as the measurements of force, power, and velocity are considered less reliable when assessed with smartphone app, and in particular in case of non-consistent technique¹⁹. We used the My Jump 2 app to measure the CMJ, which participants started from an upright standing position. The participants were instructed to begin the movement with a downward motion through knee and hip flexion, followed by an explosive and powerful extension of the knees and hips, propelling the participant off the ground before landing back on the surface. Throughout the movement, participants kept their arms positioned on their hips. The SJ participants performed by holding a squat position at the lowest point for at least 2 s before jumping as high as possible vertically (the torso rises and the legs extend), with the arms also held on the hips throughout. The lower position was standardized at 90° knee flexion, which was measured prior to testing to ensure consistency. During the flight phase, all jumps were visually monitored, and any trials with technical errors (e.g., hip/knee flexion during flight phase) were excluded from the analysis. During the 15-second repetitive hops test, participants performed continuous jumps for 15 s, keeping their hands on their hips. They were instructed to jump primarily from the ankles, with extended legs, aiming to maximize jump height while keeping ground contact time as short as possible (ideally < 250 ms). This protocol was chosen in light of unfamiliarity of drop jump tasks in Maasai, making repetitive hops a more suitable and culturally appropriate alternative. The My Jump 2 app provided an individual fatigue percentage for each participant during the 15-second repetitive hops test. In our study, these individual fatigue values were averaged across participants to obtain a group-level mean fatigue index. The % fatigue index serves as an indicator of endurance and power sustainability throughout the test, as it reflects the decline in jump height or longer contact time. A higher % of fatigue suggests a greater decrease in performance, while a lower % indicates better endurance and power maintenance during repetitive hops. Previous studies have demonstrated high reliability and validity of the My Jump 2 application compared to force plates^{20,21}.

To calculate RSI we needed jump height and contact time:

$$RSI = \frac{\text{Jump height (m)}}{\text{Contact time (s)}}$$

Statistical analysis

Statistical analysis was conducted using SPSS software (version 25). The descriptive statistics are reported as mean, standard deviation (SD), and range. The normality of data distribution was verified using the Shapiro–Wilk test and visual inspection of histograms and Q–Q plots. The groups were compared using a one-way analysis of variance (1-way ANOVA). In cases where statistically significant differences were found in the ANOVA, post-hoc t-tests with Bonferroni correction were applied. Statistical significance was accepted at $p < 0.05$. Effect sizes were calculated as eta-squared. According to revised guidelines²⁵, effect sizes of 0.10, 0.20, and 0.30 are considered small, typical, and large, respectively, indicating substantial group differences in jump performance.

Results

Table 1 shows the descriptive characteristics of the three groups, including age and body mass. The mean and standard deviation of age are reported based on data from half of the Maasai group, as the others did not know their exact birth year. However, all Maasai participants belonged to the Morani age group (16–35 years).

Table 2 shows a comparison of the CMJ and SJ jump heights results among all three groups. (Maasai, athletes and non-athletes). The SJ data for one participant was not acquired, as they were not able to learn the jump technique sufficiently for a valid assessment.

Variable	Metric	Maasai (n=30)	Athletes (n=20)	Non-athletes (n=20)
Age	Mean ± SD	28.5 ± 5.03	19.55 ± 2.35	26.7 ± 2.25
Body mass (kg)	Mean ± SD	65 ± 9.3	76.8 ± 7.6	80.3 ± 11.1

Table 1. Descriptive characteristics of Athletes, Non-Athletes, and Maasai Participants. Legend: SD – standard deviation; kg – kilograms. Note: The reported age represents only half of the Maasai participants, as the other half did not know their exact birth year. However, all Maasai participants belonged to the Morani age group, which typically includes individuals aged 16–35 years.

Outcome	Metric	Maasai (n=30)	Athletes (n=20)	Non-athletes (n=20)	F-value	p-value	Effect size (η^2)
CMJ height (cm)	Mean ± SD	38.1 ± 7.3	52.46 ± 9.07	33.72 ± 7.22	F = 32.189	p < 0.001	$\eta^2 = 0.483$
	Min./Max.	27.57 / 54.98	35.87 / 65.72	23.43 / 47.77			
SJ height (cm)	Mean ± SD	35.87 ± 6.59	49.74 ± 7.3	32.57 ± 6.21	F = 38.053	p < 0.001	$\eta^2 = 0.54$
	Min./Max.	25.71 / 51.68	36.98 / 62.03	22.94 / 44.20			

Table 2. Comparison of CMJ and SJ jump heights results between Maasai, athletes, and non-athletes. Legend: n–number of participants, CMJ–countermovement jump, Min.–minimum; Max.–maximum; SJ–squat jump, SD – standard deviation.

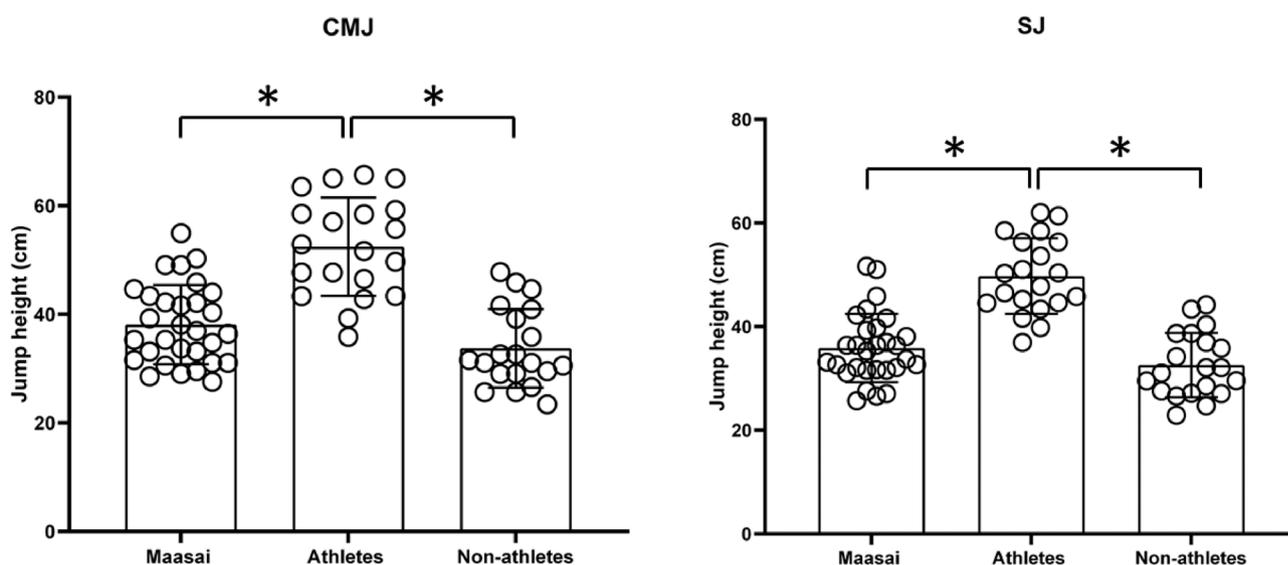


Fig. 1. CMJ and SJ performance in the Maasai, athletes and non-athletes. The figure shows mean jumps heights (cm) with standard deviations, along with individual participant data points for each group. This figure allows a visual comparison of explosive lower-body performance across the three groups.

The analysis of variance showed statistically significant differences in both CMJ and SJ jump heights among the groups (CMJ: $F = 32.189$, $p < 0.001$; SJ: $F = 38.053$, $p < 0.001$), as shown in Table 1; Fig. 1. Post-hoc analysis revealed that athletes achieved higher jump heights than both the Maasai (CMJ mean difference = 14.4 cm, $p < 0.001$; SJ mean difference = 13.87 cm, $p < 0.001$) and non-athletes (CMJ mean difference = 18.7 cm, $p < 0.001$; SJ mean difference = 17.17 cm, $p < 0.001$). However, the difference between the Maasai and non-athletes was not statistically significant for either jump type (CMJ: $p = 0.137$; SJ: $p = 0.216$). The effect sizes for the three jump types were large. For CMJ, $\eta^2 = 0.483$, indicating that 48.3% of the variance is explained by group differences. For SJ jumps, $\eta^2 = 0.54$, suggesting 54% of the variance is attributed to group differences.

Table 3 shows a comparison of the repetitive hops results among all three groups. (Maasai, athletes and non-athletes).

Analysis of variance showed statistically significant differences in mean jump height during the 15-second repetitive hops test among the groups ($F = 30.874$, $p < 0.001$), as shown in Table 2; Fig. 2. Post-hoc analysis indicated that Maasai achieved higher jumps compared to non-athletes (mean difference = 15.22 cm, $p < 0.001$). Athletes also achieved higher jumps compared to non-athletes (mean difference = 14.95 cm, $p < 0.001$), however, the difference between the Maasai and athletes was not statistically significant ($p = 0.991$). Statistically significant differences were also found in the percentage of fatigue in jump height ($F = 8.753$, $p < 0.001$). Post-

Outcome	Metric	Maasai (n=26)	Athletes (n=20)	Non-athletes (n=19)	F-value	Significance	Effect size (η^2)
Jump height (cm)	Mean \pm SD	36.2 \pm 7.75	35.93 \pm 5.98	20.98 \pm 7.07	F = 30.874	$p < 0.001$	$\eta^2 = 0.499$
	Min./Max.	24.8 / 49.79	24.47 / 48.38	11.10 / 33.49			
Fatigue (decrease) in jump height (%)	Mean \pm SD	-0.73 \pm 7.7	-15.5 \pm 12.51	-4.34 \pm 16.08	F = 8.753	$p < 0.001$	$\eta^2 = 0.22$
	Min./Max.	-13.4 / 14	-42.8 / 3.9	-41.5 / 31.30			
Ground contact time (ms)	Mean \pm SD	276.9 \pm 42.29	184.25 \pm 30.67	254.21 \pm 59.28	F = 24.925	$p < 0.001$	$\eta^2 = 0.446$
	Min./Max.	204 / 371	147 / 287	197 / 455			
Fatigue (increase) in ground contact time (%)	Mean \pm SD	15.14 \pm 12.62	11.86 \pm 14.16	12.14 \pm 10.62	F = 0.491	$p = 0.614$	$\eta^2 = 0.016$
	Min./Max.	0.2 / 48.4	0.2 / 66.10	0 / 41.60			
RSI	Mean \pm SD	1.38 \pm 0.48	2 \pm 0.45	0.85 \pm 0.31	F = 35.280	$p < 0.001$	$\eta^2 = 0.532$
	Min./Max.	0.7 / 2.4	0.85 / 2.7	0.42 / 1.42			

Table 3. Comparison of repetitive hops results between Maasai, athletes, and non-athletes. Legend: n—number of participants, Min.—minimum; Max.—maximum; RSI—reactive strength index, SD—standard deviation.

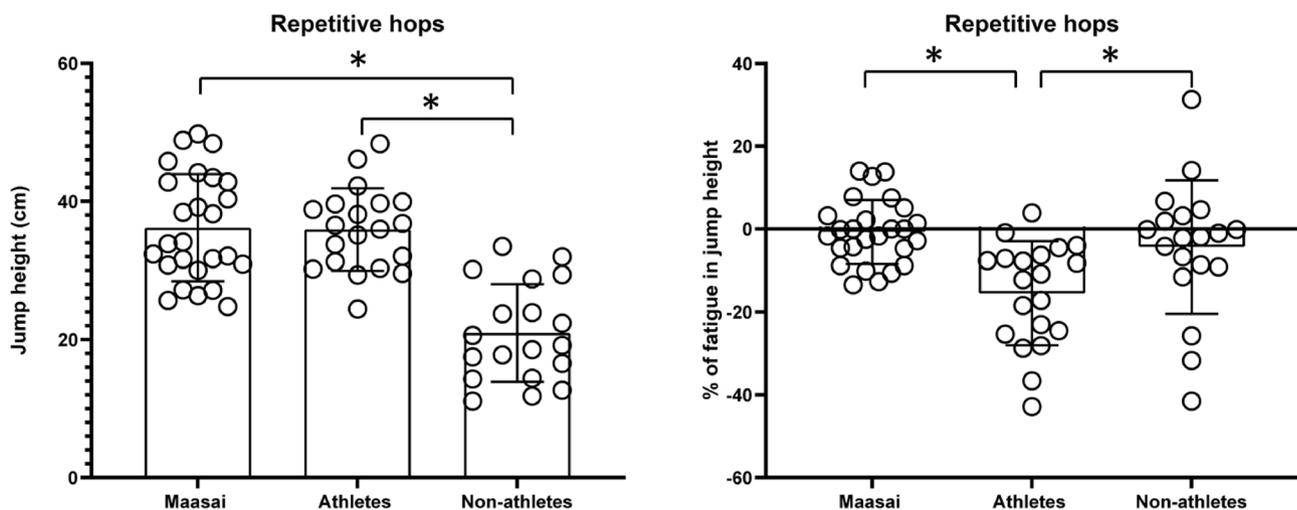


Fig. 2. Jump height and fatigue during series of repetitive hops in the Maasai, athletes and non-athletes. The figure displays mean jump height (cm), standard deviations, and individual scores, as well as the percentage decrease in jump height across the hopping protocol, representing fatigue. Participants perform hops for 15 s with hands on the hips. This figure highlights differences in jump endurance and fatigue resistance among the three groups.

hoc analysis showed that the Maasai had a higher percentage of fatigue in jump height compared to athletes (mean difference = 14.77%, $p < 0.001$), and non-athletes also exhibited a higher percentage of fatigue compared to athletes (mean difference = 11.16%, $p < 0.001$). The difference between the Maasai and non-athletes was not statistically significant ($p = 0.589$). For repetitive hops, $\eta^2 = 0.499$, indicating that 49.9% of the total variance is explained by group differences. For the percentage of fatigue in jump height, $\eta^2 = 0.22$, suggesting that 22% of the variance in jump height is attributed to fatigue.

Statistically significant differences in the mean ground contact times (Fig. 3) among the groups were observed ($F = 24.925$, $p < 0.001$), as shown in Table 2. Post-hoc analysis revealed that the Maasai had longer contact times during repetitive hops compared to athletes (mean difference = 92.63 ms, $p < 0.001$), and non-athletes also had longer contact times compared to athletes (mean difference = 69.96 ms, $p < 0.001$). The difference between the Maasai and non-athletes was not statistically significant ($p = 0.226$). For the percentage of fatigue in contact times, the analysis did not show statistically significant differences among the groups ($F = 0.491$). For ground contact time, $\eta^2 = 0.446$, indicating that 44.6% of the total variance is explained by group differences. For the percentage of fatigue in ground contact time, $\eta^2 = 0.016$, suggesting that 1.6% of the variance in ground contact time is attributed to fatigue.

Statistically significant differences were found in the RSI index among the groups ($F = 35.280$, $p < 0.001$) (Fig. 4). Post-hoc analysis indicated that athletes had a higher mean RSI compared to the Maasai (mean difference = 0.63, $p < 0.001$) and non-athletes (mean difference = 1.16, $p < 0.001$). Statistically significant differences were also observed between the Maasai and non-athletes, where the Maasai had a higher RSI than non-athletes (mean difference = 0.53, $p < 0.001$). For RSI index, $\eta^2 = 0.532$, indicating that 53.2% of the total variance is explained by group differences.

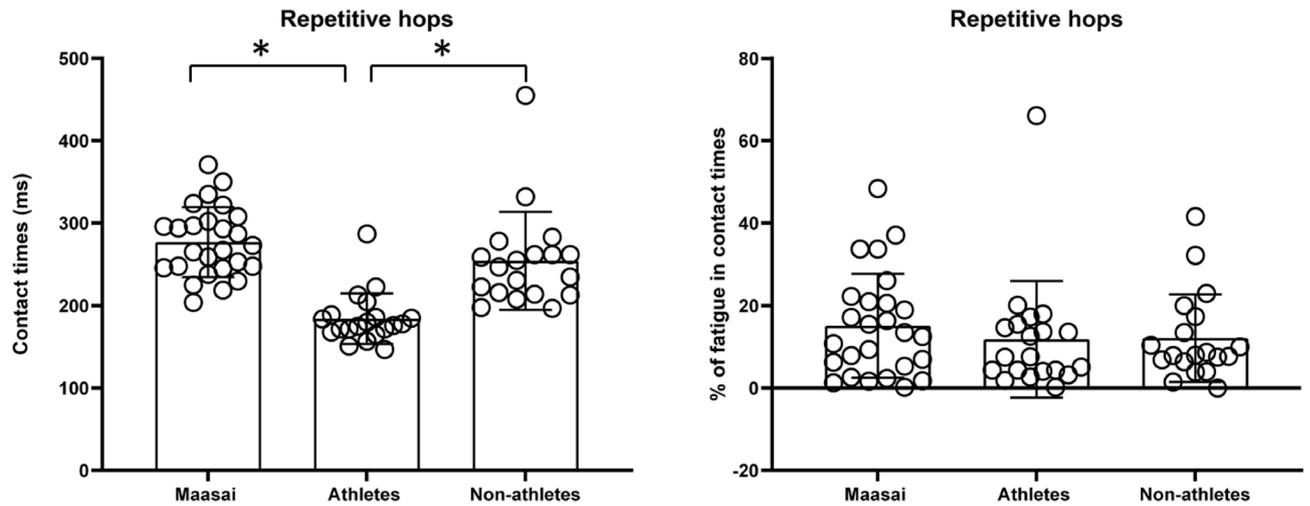


Fig. 3. Contact time and fatigue in contact time during repetitive hops in the Maasai, athletes and non-athletes. The figure presents mean contact times (ms) with standard deviations and individual values, together with percentage increase in contact time across the hopping series, used as an indicator of fatigue. This figure illustrates differences in stretch-shortening cycle efficiency and fatigue-related changes in ground contact duration among the groups.

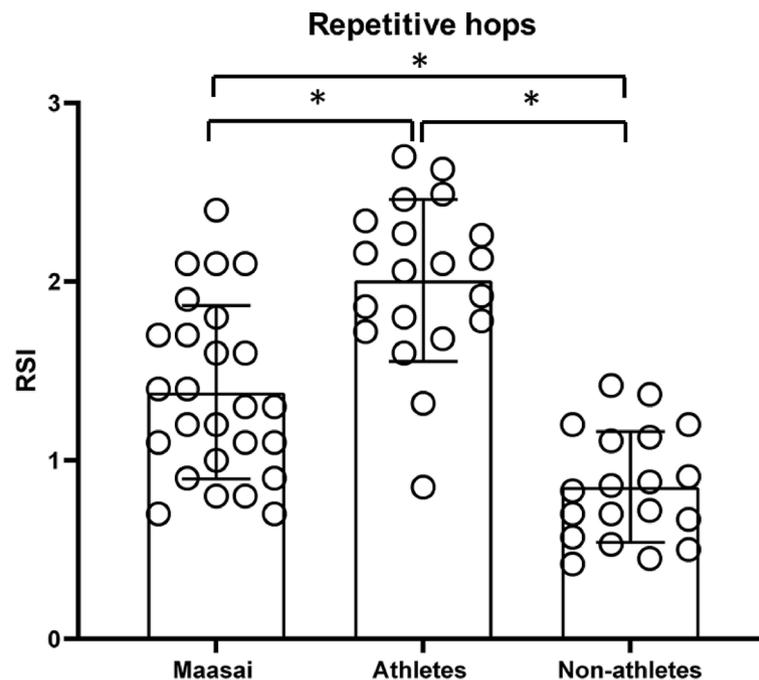


Fig. 4. RSI during repetitive hops in the Maasai, athletes and non-athletes. The figure shows mean RSI values with standard deviations and individual participant points. RSI was calculated as jump height divided by contact time, derived from the hopping protocol performed with hands on the hips. This figure provides a comparison of stretch-shortening cycle performance and reactive strength between the groups.

Discussion

The aim of this study was to compare vertical jump performance among Maasai, Slovenian athletes, and non-athletes, focusing on three jump types (CMJ, SJ, and repetitive hops). The main findings indicate that athletes demonstrated superior performance in both CMJ and SJ compared to the Maasai and non-athletes. However, in repetitive hops, the Maasai performed similarly to athletes, while non-athletes showed significantly lower performance. These results suggest that the Maasai's unique cultural practices, which involve regular jumping from a young age, may contribute to their proficiency in repetitive hops tasks.

The Maasai are renowned for their repetitive hopping ability, characterized by smooth transitions between repetitive hops. Given the lack of literature on this unique skill, we conducted this study to assess their performance in two common discrete vertical jump tests and repetitive hops. To date, only two studies have systematically examined Maasai jumping performance. One earlier investigation⁶ compared 20 Maasai participants with 8 Caucasian controls using a custom-made force plate and explored various anatomical and physiological factors contributing to their jumping ability. More recently, another study³³ involving 22 Maasai and 12 Norwegian controls provided detailed insights into muscle-tendon architecture and its relation to jump performance. Together, these studies highlight the unique biomechanical and morphological characteristics of the Maasai that may underline their exceptional jumping ability. Understanding these anatomical and physiological differences is essential to grasp the unique adaptations of the Maasai in athletic contexts. Relative to their body height, the Maasai in the aforementioned study⁶ had greater foot and hallux length but shorter lower legs compared to Caucasians. They also exhibited shorter fascicle lengths and lower muscle thickness in the gastrocnemius and vastus lateralis muscles. Additionally, their Achilles tendon and moment arm were longer, both in absolute and relative terms. These anatomical differences likely influence their jumping mechanics and performance, highlighting unique adaptations that contribute to their athletic abilities.

During the CMJ, a previous study⁶ reported a height of 33.3 ± 6.6 cm for the Maasai, lower than our group's mean of 38.1 ± 7.3 cm. That study also noted a mean jump height of 46 cm during traditional dances, allowing knee bending (knee angle of 98°), while our study involved a 15-second repetitive hops test with extended legs, yielding a lower mean height of 36.2 ± 7.75 cm. More recently, another investigation³³ expanded these findings, providing deeper insight into jump performance and muscle-tendon architecture. In that study, the Maasai achieved maximal CMJ height of 46.5 ± 4.3 cm and a repetitive jump height of 30.4 ± 6.2 cm, values comparable to Norwegian controls (46.5 ± 4.3 cm and 29.7 ± 4.6 cm).

While a previous study⁶ intended to measure SJ, it was excluded due to difficulties in eliminating countermovement, an issue we also encountered. Along with this, another study³⁴ noted that SJ often involves some concentric movement, which is difficult to eliminate without extensive repetitions. We can infer that the complete elimination of concentric movement is challenging and would require a large number of repetitions, which was not possible with our group of Maasai due to time constraints. Therefore, SJ results should be interpreted cautiously, as even a small countermovement can lead to overestimation of jump height. Although the use of force platform would allow more precise detection of countermovements³², logistical constraints prevented its use in this field study. Nonetheless, the My Jump 2 application has been shown to be a valid alternative^{17,18}. Despite these limitations, SJ was included due to its value in distinguishing between groups and jump types and in providing broader understanding of intergroup differences in jumping performance.

CMJ and SJ

In the athlete group, the mean CMJ jump height was 52.46 cm, with the highest jump recorded at 65.72 cm. My Jump application calculates jump height based on flight time, which may lead to a slight overestimation compared to the take-off velocity method; therefore, the highest recorded jump of 65.72 cm represents an exceptionally high achievement, almost unrealistic. It is important to note that both flight time and take-off velocity methods record only flight height and therefore underestimate the actual jump height (i.e., total center of mass displacement)^{35–37}, which was therefore even higher. In a study²⁶ involving 989 Norwegian male athletes, the highest CMJ heights were found among sprinters ($62.7 \text{ cm} \pm 4.8 \text{ cm}$), with mean jump heights across the sports disciplines ranging from 30 to 63 cm. In a similar study²⁸, it was also found that sprinters achieved the best results. Since bilateral vertical jumps are a form of training that elicits the highest values of anaerobic power²⁷, strength and power-oriented athletes are expected to achieve the best results. The highest Maasai jump (54.98 cm) exceeded that of our best high jumper (52.94 cm), suggesting that with targeted training, the Maasai could reach elite athletic performance levels. If we had a more homogeneous group, such as 30 Maasai and 30 high jumpers, we would likely observe more comparable results among the two groups. Well-trained athletes, particularly those who focus on strength and power training, can produce significantly higher output forces during jumping movements compared to untrained individuals. Moreover, it has been found that the output force at the point of peak power during the CMJ is higher in athletes who emphasize strength and power training compared to endurance-trained athletes²⁹.

The SJ jumps were lower than the CMJ jumps across all three groups. The highest results were achieved by the athletes ($49.74 \pm 7.3 \text{ cm}$), followed by the Maasai ($35.87 \pm 6.59 \text{ cm}$), and the non-athletes ($32.57 \pm 6.21 \text{ cm}$). The highest SJ jump recorded in the athlete group was 62.03 cm, among the Maasai 51.68 cm, and in the non-athlete group 44.20 cm. Our athlete's group SJ values were higher than those reported in a study³⁰ on sprinters ($39.51 \pm 5.09 \text{ cm}$), likely reflecting the elite status and in-season condition of our participants. Notably, the Maasai's mean SJ exceeded most sport specific groups in the same study, except sprinters.

Repetitive hops

In the 15-second repetitive hops test, the Maasai achieved a mean jump height of $36.2 \pm 7.75 \text{ cm}$, similar to the mean of athletes was $35.93 \pm 5.98 \text{ cm}$, while non-athletes had a significantly lower mean jump height of $20.98 \pm 7.07 \text{ cm}$. Despite athletes demonstrating superior performance in CMJ and SJ, the Maasai performed equally in the repetitive hops test. When comparing the fatigue percentage in jump height, the Maasai exhibited the most consistent performance ($-0.73 \pm 7.7\%$, range from -13.4 to 14%), meaning their jump heights varied less throughout the test. This consistency likely reflects long-term adaptation to repetitive hopping from early childhood, contributing to neuromuscular efficiency.

Larger variations in fatigue percentages were observed in the other two groups (athletes: $-15.5 \pm 12.51\%$, range from -42.8 to 3.9% ; non-athletes: $-4.34 \pm 16.08\%$, range from -41.5 to 31.3%). This can be explained

by the fact that the first two jumps in these groups were generally lower, and participants then jumped higher, causing greater deviations.

Regarding contact time fatigue percentage, no significant differences were observed between the groups. The Maasai had a mean fatigue percentage of $15.14 \pm 12.62\%$ (range from 0.2 to 48.4%), athletes $11.86 \pm 14.16\%$ (range from 0.2 to 66.10%), and non-athletes $12.14 \pm 10.62\%$ (range from 0 to 41.60%). In all groups, contact time was increased towards the end of the test due to fatigue.

While effective SSC utilization typically requires ground contact times below 250 ms²², the Maasai averaged longer contact times (276.9 ms) compared to athletes (184.25 ms). This likely reflects their distinctive jumping strategy, prioritizing height over rapid ground contact. Despite this, they achieved comparable jump heights to athletes, suggesting an efficient but alternative utilization of the SSC. RSI analysis supports this observation: although athletes achieved higher RSI values due to shorter contact times, the highest RSI among the Maasai (2.4), surpassed all high jumpers except the sprinter (2.7). Non-athletes, despite slightly shorter contact times (254.21 ms), showed a substantially lower RSI (0.85), primary due to reduced jump heights. This suggests that the Maasai may rely on elastic energy storage and release, combined with a minor countermovement to enhance braking and propulsion forces. Notably, a study³¹ reported a mean RSI of 1.25 ± 0.32 across athletes from various sports, which was lower than the average RSI observed in the Maasai, supporting the notion that RSI can be optimized through distinct strategies and that the Maasai's technique represents an effective alternative SSC utilization pattern. Although we did not directly assess tendon properties, previous research indicates that the Achilles tendon and other series-elastic structures can store and return elastic strain energy during cyclic movements such as hopping and running^{23,24}. Based on our observations, the Maasai's longer Achilles tendons and moment arms, likely enhance their ability to efficiently utilize elastic energy. This interpretation is further supported by recent findings³³, which provided direct evidence on muscle-tendon architecture in Maasai men.

Potential link to musculotendinous architecture

A recent study³³ reported that, although Maasai and Norwegian participants exhibited similar jump heights, the Maasai had longer relative leg and tendon lengths, lower pennation angles, and shorter fascicle lengths in the gastrocnemius and vastus lateralis muscles, accompanied by more compliant tendons. These morphological traits likely reflect long-term adaptations to habitual jumping, emphasizing efficiency and elastic energy utilization rather than explosive power.

While our study did not include direct anthropometric or architectural assessments, these findings reinforce our interpretation that regular exposure to repetitive hopping from an early age contributes to specific neuromuscular and morphological adaptations in the Maasai. The longer ground contact times observed in our study are consistent with an economical jumping strategy supported by compliant tendon structures. These similarities between our functional observations and the structural characteristics reported in a recent study³³ suggest that habitual jumping promotes adaptations enhancing movement efficiency within the SSC.

This consistency, paired with a higher RSI than the non-athletes and comparable to that of athletes, underscores the potential role of their habitual jumping in developing effective SSC mechanisms, despite less emphasis on explosive power training. However, these results should be interpreted with an understanding that different Maasai clans may exhibit distinct characteristics shaped by their specific cultural contexts. Through oral traditions the Maasai community in Tanzania consists of four clans, each with unique traditions, customs, and practices. This diversity underscores the importance of considering clan-based differences when analyzing and interpreting data related to the Maasai community.

Limitations

This study has several limitations that should be considered when interpreting the findings. First, anthropometric characteristics were not assessed, limiting our ability to account for individual morphological differences that may influence jumping performance. Second, the testing was conducted on different surfaces, which may have affected jump mechanics and confounded group comparisons. Additionally, the study focused on a single Maasai clan; thus, the findings may not be generalizable to other clans due to potential cultural variability. Another limitation concerns the age difference between the groups. The Maasai and non-athletes were, on average, older than the athletes, which may influence jump performance, as vertical jump heights tend to decline with age after the mid-twenties. Future studies should aim to include age-matched groups to better isolate the effects of training and habitual jumping. Lastly, the unequal sample sizes across groups—30 Maasai, 20 athletes, and 20 non-athletes—may have influenced statistical power and the reliability of between-group comparisons. A more balanced design would enhance comparability and strengthen the conclusions.

Conclusion

This study highlights notable differences in jumping performance across culturally and athletically distinct groups. Athletes demonstrated the highest jump heights in CMJ and SJ, reflecting the benefits of structured training. However, the Maasai performed equally well as athletes in repetitive hops and significantly better than non-athletes, despite not engaging in formal training. These findings suggest that habitual physical activities embedded in cultural practices, such as repetitive jumping, may lead to distinct adaptations that support efficient movement. The results emphasize the relevance of considering cultural and lifestyle factors when evaluating athletic performance and motor capabilities. Furthermore, this study underscores the value of incorporating diverse populations into performance research, as doing so may broaden our understanding of human movement and inform the development of more inclusive and adaptable training approaches.

Data availability

The datasets generated and/or analyzed during the current study are not publicly available due to participant confidentiality, institutional policy, and restrictions imposed by the ethics committee, as well as the presence of sensitive health information not covered by public data sharing agreements. However, the data are available from the corresponding author on reasonable request.

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Author contributions

P.R. and Z.K. conceptualized the study. P.R. collected the data. E.K. and J.C. supervised the measurements and contributed to data collection and organization. All authors participated in data analysis and discussion. P.R. wrote the main manuscript draft. All authors provided feedback and worked on the final version of the manuscript.

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Declarations

Competing interests

The authors declare no competing interests.

Additional information

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