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Energy expenditure and intensity of ritual jumping–dancing in male Maasai

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Abstract

Objectives: Traditional jumping–dance rituals performed by Maasai men involve prolonged physical exertion that may contribute significantly to overall physical activity level. We aimed to objectively quantify the metabolic intensity of jumping–dance activity and assess associations with habitual physical activity and cardiorespiratory fitness (CRF).

Methods: Twenty Maasai men (18–37 years) from rural Tanzania volunteered to participate in the study. Habitual physical activity was monitored using combined heart rate (HR) and movement sensing over 3 days, and jumping–dance engagement was self-reported. A 1-h jumping–dance session resembling a traditional ritual was organized, during which participants' vertical acceleration and HR were monitored. An incremental, submaximal 8-min step test was performed to calibrate HR to physical activity energy expenditure (PAEE) and assess CRF.

Results: Mean (range) habitual PAEE was 60 (37–116) kJ day^{-1} kg^{-1}, and CRF was 43 (32–54) mL O_2 min^{-1} kg^{-1}. The jumping–dance activity was performed at an absolute HR of 122 (83–169) beats·min^{-1}, and PAEE of 283 (84–484) J min^{-1} kg^{-1} or 42 (18–75)% when expressed relative to CRF. The total PAEE for the session was 17 (range 5–29) kJ kg^{-1}, ~28% of the daily total. Self-reported engagement in habitual jumping–dance frequency was 3.8 (1–7) sessions/week, with a total duration of 2.1 (0.5–6.0) h/session.

Conclusions: Intensity during traditional jumping–dance activity was moderate, but on average sevenfold higher than habitual physical activity. These rituals are common, and can make a substantial contribution to overall physical activity in Maasai men, and thus be promoted as a culture-specific activity to increase energy expenditure and maintain good health in this population.

1 | INTRODUCTION

Physical activity in rural sub-Saharan Africa is high (Assah et al., 2009; Christensen et al., 2009; Christensen, Faurholt-Jepsen, et al., 2012) but likely declining (Sobngwi et al., 2003). For example, Kenyan Maasai ($n = 341$) have very high physical activity energy expenditure (PAEE) at an average of 78 and 74 kJ day^{-1} kg^{-1} in 40-year old men and women, respectively as measured by combined heart rate (HR) and accelerometry (Christensen, Faurholt-Jepsen, et al., 2012). This total volume of activity is mainly comprised of relatively low intensity activity; men and women only spend 13.5% and 13.2% of time in moderate-to-high intensity, respectively (>3 times resting metabolic rate, or metabolic equivalents of task [METs]) (Christensen, Faurholt-Jepsen, et al., 2012). The intensity distribution is reflected in moderate cardiorespiratory fitness (CRF) levels in 40-year old Maasai men (43 mL O_2 min^{-1} kg^{-1}) and women (39 mL O_2 min^{-1} kg^{-1}), which is similar to other rural populations in Kenya (Christensen, Faurholt-Jepsen, et al., 2012). More recently, a smaller group of rural and semi-urban Maasai men from Tanzania ($n = 21$) with a mean age of 43 years were reported to have substantially lower PAEE and CRF at 55 kJ day^{-1} kg^{-1} and 34 mL O_2 min^{-1} kg^{-1}, respectively (Christensen et al., 2021). This could indicate a secular decline in activity and fitness levels, perhaps as a result of increased urbanization, highlighting the need to identify culturally relevant activities which allow maintaining a higher level of physical activity.

The agro-pastoralist Maasai, who reside in Tanzania and Kenya, are known for their unique frequent jumping–dance activities (*Adumu* in the Maasai language, Ol-Maa) in relation to social events. These could be circumcision ceremonies (*Emorata* in Ol-Maa), or the coming-of-age ceremony of the warriors (*Eunoto* in Ol-Maa) where men around the age of 30 years become junior elders. This social "graduation" allows them to marry (Amin et al., 1987; Saitoti & Beckwith, 1980). A typical jumping–dance event would see a group of men stand in a line or half-circle and sing, and one to three of them will step in front of the line and start jumping, then re-join the line of fellow Maasai, shortly after which one or more individuals will initiate another bout of jumps (Amin et al., 1987; Saitoti & Beckwith, 1980). Jumping–dance events may last up to several hours, even through the night including breaks, and Maasai women sometimes join the events facing the men while singing and dancing, but only men perform the jumping activities (Amin et al., 1987; Saitoti & Beckwith, 1980). The purpose of the jumps is to portray the athletic skills of the Maasai by making the jumps look as effortless as possible, and to compete for height and number of repetitions with the other participating Maasai. Furthermore, the jumping–dance activities serve as an expression of masculinity, displaying individual strength, courage and endurance, which may ultimately determine status, both current and later as a junior elder for each individual (Amin et al., 1987). Formal ritual jumping–dance events often take place close to an *engan'g* (cluster of homes for men, women, and children), whereas informal events are more likely to take place close to a *manyatta* (cluster of homes for men only). Maasai men of all age groups do jumping–dance activities, but only with individuals from the same age group, that is, a circumcision group.

Our previous studies of PAEE did not specifically consider ritual jumping–dance activity as part of the overall physical activity pattern in traditional, male Maasai. Therefore, the aim of this study was to objectively assess PAEE during a jumping–dance ceremony in Maasai men and quantify its contribution to habitual physical activity. As this culture-specific jumping–dance activity has never been studied before from a physical activity perspective, we also aimed to quantify how common such events are, in terms of frequency and duration.

2 | MATERIALS AND METHODS

2.1 | Study setting and population

Male Maasai in Monduli District, Arusha Region of Tanzania were informed about the study and encouraged to participate by one of the coauthors (Joseph Sironga), who is Maasai. Eventually, 24 individuals agreed to participate in the study and signed a consent form or in case of illiteracy signed with a thumb print. Two were considered too young at 14 and 15 years of age based on their own account as they were not yet circumcised, and another two did not show up for the step test for assessment of aerobic fitness, nor for the jumping–dance event. Thus, 20 Maasai participated in the study, which took place in January 2016 in Monduli Juu (upland Monduli, about 30 min. drive outside of Monduli Town). We used an indoor makeshift lab for all measurements except for the jumping–dance event, which took place in a closed compound just outside the makeshift lab at an altitude of ~1700 m above sea level. Ethical approval was granted by Tumaini University, Moshi (certificate no. 507).

2.2 | Participant characteristics: anthropometric and clinical measurements

Anthropometric measurements (weight, height, waist, and hip circumference) were carried out by a trained investigator (Dirk L. Christensen) using an electronic scale, a portable stadiometer, and a nonstretchable tape, respectively. Body mass index (BMI, kg/m^2) and waist–hip ratio were calculated.

Using a fully automated blood pressure device (OMRON M8, Kyoto, Japan) blood pressure and HR were measured three times by a trained nurse with each participant in the sitting position and after 15 min. of rest, and allowing 2 min. between measurements. The first measurement was used to familiarize each participant with the procedure, and thus not used for the final calculation. After an overnight fast, a blood sample (10 mL) was taken in order to analyze plasma glucose, standard lipid profile, and C-reactive protein using Cobas 8000 modul c702 (Roche Diagnostics International AG, Rotkreuz, Switzerland), and serum insulin using Cobas 8000 c602 (Roche Diagnostics International AG, Rotkreuz, Switzerland), as well as hemoglobin using point-of-care device Hb 201 RT (HemoCue AB, Ängelholm, Sweden). Insulin resistance was calculated using the homeostasis model assessment insulin resistance formula: fasting insulin (pmol/L) × fasting glucose (mmol/L)/135 (Stumvoll et al., 2000).

2.3 | Assessment of cardiorespiratory fitness

On a separate day prior to the jumping–dance session, CRF was assessed using HR response to a submaximal exercise test. HR was measured using a combined uniaxial accelerometer and HR sensor (Actiheart, Cambridge Neurotechnology, Cambridge, UK). The monitor was applied to the chest on two electro-cardiogram electrodes (Unomedical A/S, Lejre, Denmark); a medial electrode placed at the lower part of the sternum, and a lateral electrode placed on the same horizontal level without stretching the wire below the major pectoral muscle (Brage et al., 2006). Each participant was asked to perform an 8-min step test stepping up and down a 21.5-cm high step. The stepping frequency was increased from 15 step cycles (body lifts) in the first minute to 33 steps per minute at the end. Upon termination, sitting recovery was monitored for 2 min. The individual relationship between HR and per-protocol-energy cost of stepping was derived by linear regression, and recovery HR was summarized as quadratic regression against recovery time up to 90 s and solved for 1-min as previously described (Brage et al., 2007). To obtain an estimate of CRF (expressed as ml O_2 min^{-1} kg^{-1}), the individually established submaximal HR to activity energy expenditure relationship was extrapolated to age-predicted maximal HR (Tanaka et al., 2001), to which we added an estimate of resting metabolic rate (Henry, 2005), and converted the result by the energetic value of oxygen. This approach captures two thirds of the between-individual variation in physiological response to longer lab-based treadmill exercise tests performed to 90% of max (Brage et al., 2007). Step test duration >4 min was required for CRF estimation.

2.4 | Assessment of habitual physical activity

The study participants were asked to wear the combined HR and movement sensor continuously over the following 3 days including nights, while continuing their normal daily activities. Data were collected in 1-min resolution. HR data were preprocessed using a robust Gaussian Process Regression method (Stegle et al., 2008). Sleeping HR, average HR above sleep and body movement (accelerometry) during free-living were calculated from these data. Furthermore, PAEE was modeled using step-test calibrated HR combined with movement in a branched equation modeling framework (Brage et al., 2007) as previously validated (Assah et al., 2011). Time spent in physical activity intensity categories (METs), that is, with thresholds 0.5, 0.5–3, and >3 METs regarded as sedentary, time in light activity, time in moderate-to-vigorous activity, were calculated, and the physical activity data required 24 h of valid data to make PAEE assessment.

2.5 | Jumping–dance event

The jumping–dance event took place immediately following the habitual monitoring period. The event was organized for the purpose of the study, and was designed to mimic a cultural celebration jumping–dance event as closely as possible for a minimum of 1 h. In order to ensure event-specific authenticity, the pre-event ritual of consuming *leshoro* (boiled milk and white maize mixed together), and roasted goat meat was organized in the early morning of the event and was initiated at 11 am. Two Maasai women turned up to dance and chant in front of the Maasai men to mimic the common cultural framing of the event (no measurements were done in the women).

The combined HR and movement sensor was initialized to collect data at 15-s resolution, and study participants also wore a tri-axial accelerometer (AX3, Axivity, Newcastle upon Tyne, UK) taped onto their chest on the upper part of the sternum. The raw tri-axial acceleration data (measured at 800 Hz at ±4 g range) was calibrated to local gravitational acceleration (in *g*) (van Hees et al., 2013), from which Vector Magnitude was calculated. In order to isolate the activity-related acceleration component, the gravitational acceleration component was removed by applying a high-pass filter (0.2-Hz frequency threshold) to derive High-Pass Filtered Vector Magnitude (White et al., 2016). We reduced this to averages over 15-s intervals, expressed in units m/s^2.

Finally, a questionnaire (inter-active interview performed in Ol-Maa) was used to assess habitual engagement in jumping–dance activities, including age at first formal or informal event, frequency and duration of events in a typical week as well as injuries related to jumping.

2.6 | Statistics

Continuous variables were presented as mean (SD) or median (25%; 75% IQR) depending on whether data had normal or skewed distribution, respectively. We used linear regression analyses to determine the association between habitual PAEE and ritual PAEE during jumping–dance activity versus CRF, high (≥3.0) METs, formal/informal jumping–dance frequency and duration. P-value <0.05 was regarded as statistically significant, and we used Stata 17.0® (College St., TX, USA) as software for all analyses.

3 | RESULTS

Participant characteristics are shown in Table 1. Average age was 25.4 (range 18–37) years, mean BMI was 19.1 (range 15.4–22.8) kg/m^2, and mean hemoglobin level was 15.9 (range 13.4–18.1) g/dL. Anthropometric and cardiometabolic characteristics were similar to those, previously found in Maasai men within same age range (Lee et al., 2019).

An example of habitual monitoring of movement and heart rate as well as an example from jumping–dance activity from one study participant are shown in Figure 1a,b, respectively. Summary statistics for CRF, PAEE and jumping–dance data are presented in Table 2. Jumping–dance activity was performed with a mean absolute HR of 122 (range 83–169) beats·min^{-1}, whereas mean absolute HR during habitual PAEE was 76 (range

TABLE 1 Background characteristics of male Maasai jumpers (n = 20).

Variable	Mean	SD	Range
Age (years)	25.4	5.5	18–37
Anthropometry/body composition[a]			
Height (cm)	170.1	7.1	152.0–181.7
Weight (kg)	55.5	6.6	43.3–69.6
Body mass index (kg/m^2)	19.1	1.7	15.4–22.8
Waist circumference (cm)	74.6	4.3	69.4–87.4
Hip circumference (cm)	89.0	4.7	80.1–97.6
Waist-hip ratio	0.84	0.04	0.79–0.92
Hemodynamics			
Systolic blood pressure (mmHg)	107.9	9.9	85–127
Diastolic blood pressure (mmHg)	75.7	9.0	55–95
Sitting heart rate (bts/min)	68.4	10.6	48–96
Biochemistry[a]			
Hemoglobin (g/dL)	15.9	1.1	13.4–18.1
Plasma glucose (mmol/L)	4.7	0.7	3.4–7.0
Serum insulin (pmol/L)[b]	37	21;55	9–213
HOMA-IR[b]	1.3	0.7;1.9	0.3–11.0
Total plasma cholesterol (mmol/L)	3.5	0.6	2.4–4.7
Plasma HDL (mmol/L)	1.08	0.23	0.49–1.48
Plasma LDL (mmol/L)	2.0	0.7	0.9–3.3
Plasma triglyceride (mmol/L)	0.7	0.2	0.4–1.1
Plasma C-reactive protein (mg/L)[b]	0.9	0.3; 2.2	0.3–36.3

Abbreviations: HOMA-IR, homeostasis model assessment insulin resistance (fasting insulin [pmol/L] × fasting glucose (mmol/L)/135); HDL, high density lipoprotein cholesterol; LDL, low density lipoprotein cholesterol.

[a]All measurements and analyses are based on fasting blood.

[b]Skewed distribution, presented as medium (IQR).

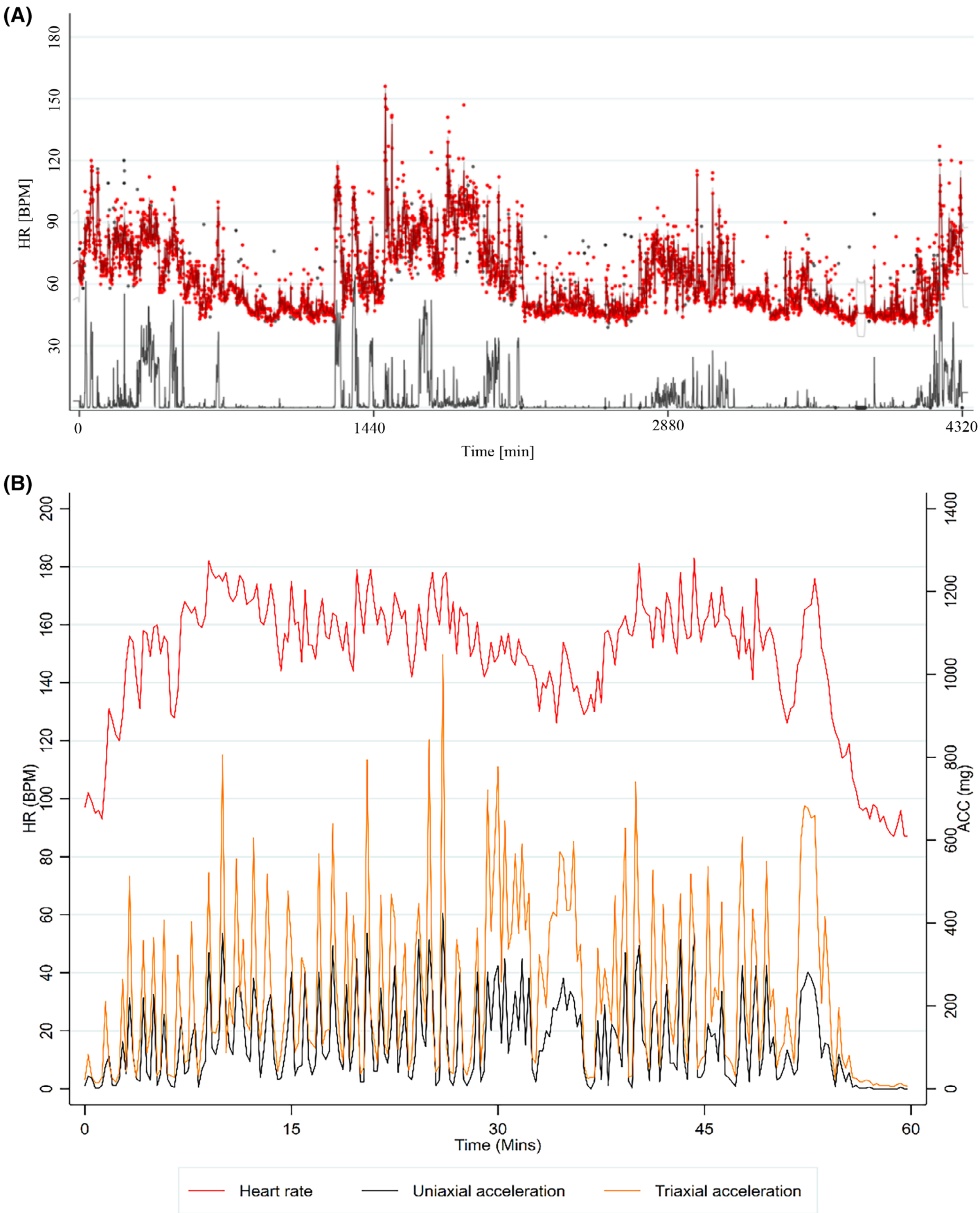

FIGURE 1 (A) Example time series of uni-axial acceleration and heart rate data for study participant across 3 days. (B) Example time series of heart rate, uni-axial and tri-axial acceleration during 1 h of jumping–dance activity.

63–86) beats·min^{-1}. Mean PAEE during the jumping–dance event was estimated at 283.1 (range 84.0–484.3) J min^{-1} kg^{-1}, whereas mean PAEE during free-living was 41.8 (range 25.4–80.8) J min^{-1} kg^{-1}. Mean jumping–dance intensity was therefore 6.8-fold higher compared to average daily PAEE.

When integrated over time, PAEE for the 1-h jumping–dance session was 17.0 (range 5.0–29.1) kJ · kg^{-1}, amounting to about 28% of the daily energy spent on physical activity.

Questionnaire data on jumping–dance activities are presented in Table 3. Frequency and duration refers to a

TABLE 2 Cardiorespiratory fitness, habitual physical activity, and jumping–dance activity levels in male Maasai ($n = 20$).

Variable	Mean/median	SD/IQR	Range
Fitness and physical activity[a]			
Sleeping heart rate (bts min^{-1})[b]	54	5	44–63
Post-step recovery heart rate above sleep (bts min^{-1})[b,c]	27	12	6–48
Cardiorespiratory fitness (mlO_2 min^{-1} kg^{-1})	43.0	4.9	32.4–53.9
Habitual heart rate above sleep (bts min^{-1})[b]	22	3	18–28
PAEE (kJ day^{-1})[b,d]	3371	1262	2013–7083
PAEE (kJ day^{-1} kg^{-1})[b,d]	60.1	19.5	36.6–116.3
PAEE (J min^{-1} kg^{-1})[b,d]	41.8	13.5	25.4–80.8
Sedentary time (%)[b,e]	56.4	10.2	26.2–73.7
Time in light activity (%)[b,f]	28.3	6.3	15.1–38.6
Time in moderate-to-vigorous activity (%)[b,g]	15.4	7.7	6.3–36.8
Jumping-dance activity[a,h]			
Heart rate above sleep (bts min^{-1})[i]	68	20	26–106
Uni-axial movement (m s^{-2})[a,j,k]	0.36	0.08;1.34	0.35–1.68
Tri-axial movement (m s^{-2})[h,j,k]	0.67	0.28;2.38	0.69–2.31
PAEE (J min^{-1} kg^{-1})[d,l]	283.1	150.8	84.0–484.3
Proportion of daily habitual PAEE (%)[m]	28.3	10.1	8.4–48.3
Relative intensity (%)[n]	41.8	13.6	18.4–74.7

[a]Data based on heart rate, accelerometry, or combined heart rate and uni-axial (vertical) accelerometry.
[b]$n = 19$.
[c]Recovery heart rate at 1-min post-step test (based on 90-s regression), expressed above sleep heart rate.
[d]PAEE, physical activity energy expenditure.
[e]Time spent at intensity <1.5 Metabolic Equivalent of Task (MET).
[f]Time spent at intensity 1.5–3.0 METs.
[g]Time spent at intensity >3.0 METs.
[h]Based on tri-axial accelerometry.
[i]Net heart rate is heart rate above sleep.
[j]$n = 15$.
[k]Skewed distribution, presented as median (IQR).
[l]Activity intensity during jumping-dance activity without resting energy expenditure.
[m]PAEE during jumping as percentage of daily habitual PAEE.
[n]Activity intensity relative to aerobic fitness.

combination of formal and informal events. There were no significant correlations between habitual or jumping–dance PAEE intensity, self-reported frequency or duration of jumping. Six (30%) of the participants had a history of lower leg injury (right shin $n = 4$, left knee $n = 1$, right knee $n = 1$), while one (5%) participant had a lower leg injury (right foot) during the time of the study. During the jumping–dance event, we observed 10–30 synchronized jumps in a bout to be the typical pattern.

4 | DISCUSSION

We measured intensity and energy expenditure of jumping–dance activity for 1 h in a group of rural, Tanzanian Maasai men, and showed that this typical cultural activity is of moderate-to-high intensity, with considerable interindividual variation. Expressed relative to fitness, jumping–dance intensity was ~42%, ranging between 18% and 75%. Even though this is low on average, jumping–dance session durations typically last at least 2 h, and the total extra energy expended amount to at least 28% of the total daily activity energy for each hour of jumping–dance activity.

We also estimated the total physical activity energy expenditure during the 1-h jumping–dance event (17 kJ kg^{-1}) to amount to over a quarter of the daily energy spent on activity, suggesting this type of activity could be promoted for increasing or maintaining high levels of activity in this population, particularly in the

TABLE 3 Self-reported frequency and duration of jumping-dance activity, and correlations with objectively measured habitual and jumping-dance physical activity energy expenditure levels in male Maasai (n = 20).

Variable	Mean	SD	Range
Self-reported jumping-dance activity			
Frequency/week	3.8	2.0	1–7
Duration per session (hours)	2.1	1.9	0.5–6.0
Hours/week (frequency × duration per session)	8.8	10.1	1–30
Regression analyses[a,b]	**β**	**95% CI**	***p*-Value**
Habitual PAEE and frequency/week[c]	−0.7	−5.8;4.3	.76
Habitual PAEE and duration/session[c]	−0.2	−5.3;4.9	.94
Habitual PAEE and hours/week[c]	−0.1	−1.0;0.9	.88
Habitual PAEE and jumping-dance PAEE[c]	0.01	−0.01;1.0	.86
Habitual PAEE MV intensity and frequency/week[c]	−0.7	−2.7;1.3	.46
Habitual PAEE MV intensity and duration/session[c]	0.4	−1.6;2.4	.67
Habitual PAEE MV intensity and hours/week[c]	0.02	−0.4;0.4	.92
Habitual PAEE MV intensity and jumping-dance PAEE[c]	0.0	−0.03;0.04	.81
Jumping-dance PAEE and frequency/week	17.7	−5.4;40.9	.13
Jumping-dance PAEE and duration/session	14.4	−10.9;39.7	.25
Jumping-dance PAEE and habitual PAEE	2.9	−1.8;7.7	.21

[a]PAEE, physical activity energy expenditure.
[b]MV intensity, moderate-vigorous physical activity intensity = Time spent at intensity >3.0 METs.
[c]$n = 19$.

face of rapid urbanization. From a health perspective, participation in such events will improve the overall cardio-metabolic health as shown in Kenyan Maasai (Lee et al., 2019). We have previously estimated that for every 10 kJ kg^{-1} day^{-1}, which amounts to one 35-min jumping–dance session per day, waist circumference was 1.8 cm lower, systolic blood pressure 1.5 mmHg lower, fasting insulin 0.27 pmol/L lower, and 2-h glucose following an oral glucose tolerance test 0.17 mmol/L lower in the Maasai. These are all established risk factors for cardiovascular disease and diabetes, suggesting a daily session of jumping–dance may significantly lower the risk of developing such diseases. Importantly, the same study also showed that very low activity levels had a more detrimental effect in Maasai compared to other ethnic groups in Kenya (Lee et al., 2019), emphasizing the importance of maintaining the jumping–dance events in Maasai culture for health purposes.

Nevertheless, we were not able to show any correlation between self-reported jumping–dance frequency, time spent on jumping–dance sessions with neither habitual PAEE nor jumping–dance PAEE, indicating a weak intercorrelation between habitual and ritual activity patterns.

Jumping activity is based on alternating between near maximal counter movement jumping bouts and waiting while standing up and chanting. As indicated by the example given in Figure 1b, there was no HR drift, and thus full recovery between the jumping bouts. Each individual had to wait his turn before initiating a new jumping bout alone or with others. This may at least partly explain why there is a lack of relationship between habitual PAEE, CRF, and activity intensity during the jumping–dance event. Ritual jumping–dance events are based on structured order of movement patterns where each participant can only fully display his jumping abilities within this frame. It is of note that mechanical efficiency is higher in counter-movement jumps as performed in repetitive jumping by the Maasai compared to repetitive static jumping, which may reflect optimal muscle-tendon unit kinetics and usage of stored elastic energy (McCaulley et al., 2007).

This is of importance when jumping–dance activities last for several hours, and each participant must preserve energy. In Africa, such energy preserving mechanisms for habitual physical tasks have previously been observed. Two separate studies, (Heglund et al., 1995;

Maloiy et al., 1986) have shown experimentally that women of Luo and Kikuyu ethnicity in Kenya have developed an energy-saving gait while carrying loads on their head. More specifically, these African women were able to carry loads up to 20% of their body weight without increasing their rate of energy consumption (Heglund et al., 1995; Maloiy et al., 1986). Furthermore, young men from The Gambia had higher net efficiency compared to European men (23.2% vs. 20.1%) when walking on a treadmill at 3.2 km h^{-1} at 0% and 10% elevation (Minghelli et al., 1990). As the jumping–dance activities are of high social importance in Maasai culture, including also impressing the opposite sex for marriage purposes (Amin et al., 1987), it is likely that energy preservation has become an important trait in order to endure long-term jumping activity.

CRF was similar (43.0 vs. 43.1 mL O_2 min^{-1} kg^{-1}) in the Tanzanian compared to Kenyan Maasai aged 40 years. It is of note that we previously showed an inverse age-related fitness change of 4.4 mLO_2 min^{-1} kg^{-1} for every 10 years difference in the Kenyan Maasai (Christensen, Faurholt-Jepsen, et al., 2012). All in all, and taking the age-difference between the Tanzanian and Kenyan study populations into account (25 vs. 40 years of age, respectively), CRF seems to be maintained from young adulthood to mature adulthood; thus in Maasai culture from the stage of being warrior (*moran* in Ol-Maa) to the stage of becoming an elder (*payiani* in Ol-Maa) (Saitoti & Beckwith, 1980). Similar CRF (±10%) results in other populations have been shown such as in young indigenous Siberians (Evenki and Keto) (Katzmarzyk et al., 1994), and in middle-aged indigenous Mexican Tarahumara/Rarámuri individuals (Christensen, Alcala-Sanchez, et al., 2012). Similarly, occupational groups, that is, former and present cattle herders compared to noncattle herders among East African Turkana had an impact on CRF in young as well as middle-aged men (20–49 years of age) (Curran-Everett, 1994). In relation to work capacity, Spurr et al. showed a positive relationship between CRF and productivity among Columbian sugar cane cutters, and that with increasing age, a greater percentage of CRF had to be utilized in order to maintain productivity (Spurr et al., 1977).

Absolute habitual PAEE was substantially lower compared to previous results in Kenyan Maasai, which we collected a decade earlier (78 vs. 60 kJ day^{-1} kg^{-1}, respectively) despite the fact that the results given for the Kenyan Maasai were based on 40-year old individuals (Christensen, Faurholt-Jepsen, et al., 2012), whereas the average age in the current study participants was 25 years. Whether the difference is due to a chance finding, reflects a decline in current activity patterns, or other factors can only be speculated upon at this stage. More systematic and comparative studies need to be carried out in order to answer the question. On the other hand, absolute habitual PAEE based on 41-year old Mexican Tarahumara/Rarámuri, an indigenous people with a tradition for high activity levels (Christensen, Alcala-Sanchez, et al., 2012), was similar to the current results (64 vs. 60 kJ day^{-1} kg^{-1}, respectively), indicating that relatively high activity levels in rural Maasai are maintained when compared to other indigenous populations living in rural areas.

As jumping–dance intensity is ~sevenfold higher than daily habitual PAEE, this traditional event specific to Maasai culture is likely to contribute substantially to overall PAEE taking self-reported data of frequency (3.8 times/week) and duration (2.1-h/event) into account. Even if quantification of events or activity need to be interpreted with caution, as the Maasai do not have a tradition for quantifying such matters based in our experience, all in all the data at hand seem convincing. Add to this that one coauthor (Joseph Sironga) himself being a Maasai, has first-hand experience with jumping–dance events, and he confirms the interpretation put forward.

4.1 | Cultural implications

Pagel (2012) suggested that transmitting skills is a survival strategy for humans. While transmitting jumping–dance skills among the Maasai may not be a direct survival strategy from a biological perspective, it is likely that these skills are an important trait for defining Maasai identity, and in effect favor those individuals whose jumping–dance skills are superior in relation to social status, and possibly choice of partner. Furthermore, as courage is one of the traits shown in a jumping–dance event (Amin et al., 1987), skillful jumpers may also have been good warriors during the days when this was essential. Thus, all these aspects put together, the jumping–dance tradition may be a biological–cultural interaction survival strategy linked to traditional Maasai culture.

There are limitations to the study. While >1 h of activity would have been optimal and closer to common cultural events, we were still able to capture jumping–dance duration at the low end based on self-reported information (min. 0.5 h). Lastly, we cannot exclude the possibility that the lack of statistically significant findings could be due to the low number of study participants as variation in intensity during jumping and habitual physical activities was substantial. Nevertheless, we believe that a representative group of Maasai participated in the study based on the substantial variety of self-reported time (duration 0.5–6.0 h per event) and frequency (1–7 times/week) spent on jumping–dance activities.

5 | CONCLUSION

In conclusion, Maasai men performing 1 h of their traditional jumping–dance activity did this at moderate intensity and ~sevenfold higher intensity than activity intensity during daily life. Only an average of 42% of the CRF level was utilized while doing bouts of repeated near maximal counter-movement jumping combined with breaks while standing up; still a single 1 h jumping–dance session amounts to over a quarter of daily activity energy, and can thus play a role in reducing the burden of cardio-metabolic disease in this population. The current study is the first to quantify jumping–dance activity (energy expenditure and intensity) in Maasai men, and shows that it can play a substantial part in maintaining a healthy level of daily activity.

AUTHOR CONTRIBUTIONS

Dirk L. Christensen, Jorgen Jensen, and Soren Brage conceptualized the study; Joseph Sironga and Dirk L. Christensen organized the field study; Dirk L. Christensen, Jorgen Jensen, and Joseph Sironga collected the data; Kate Westgate and Lewis Griffiths processed and "translated" the raw physical activity data into formal units; Dirk L. Christensen and Soren Brage did the statistical analyses; Venance P. Maro, Jørn W. Helge, Steen Larsen, Ib C. Bygbjerg and Kaushik L. Ramaiya assisted in the coordination of the study including ethical approval of the protocol; Dirk L. Christensen drafted the manuscript; All authors have read and approved the final version of the manuscript, and agree with the order of presentation of the authors.

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CONFLICT OF INTEREST STATEMENT

None of the authors have a conflict of interest to declare.

DATA AVAILABILITY STATEMENT

Research data are not shared, as ethical approval and permission to publish has been granted to the corresponding author and co-authors of this research article. Any external access to the data will have to be granted via the ethical committee at Tumaini University (Kilimanjaro Christian Medical University College) in Moshi, Tanzania.

ETHICS STATEMENT

Ethical approval was granted by Tumaini University, Moshi, Tanzania (certificate no. 507). Participation was based on informed consent and signing the consent information or in case of illiteracy with a thumb print. Participation was voluntary and participants were informed that they could withdraw from the study at any time. Inclusion criteria were being of male sex as women do not perform the jumping–dance activities, and to have been circumcised, as non-circumcised individuals are not considered as adults in Maasai culture. Thus, participation in jumping–dance activities would therefore be less frequent in non-circumcised individuals, who would not be allowed to participate in certain rituals as active jumping–dancers, and thus not be representative of full integration of jumping-dance events into daily or ritual life activities.

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