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Performance characteristics of Parkour practitioners: Who are the traceurs?

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Abstract
Parkour is a modern physical activity that consists of using the environment, mostly urban, as a playground of obstacles. The aims of this study were (i) to investigate age, anthropometric and training characteristics of Parkour practitioners, called 'traceurs' and (ii) to assess jump performances and muscular characteristics of traceurs, compared to those of gymnasts and power athletes. The mean age of the population of traceurs studied ($n = 130$) was 19.4 ± 4.3 years, women represented 12.4% of the total field and mean training volume was 8.1 ± 0.5 hours/week. Vertical and long jump performances were analysed on smaller samples of participants (four groups, $n = 15$ per group); and eccentric ($-90° s^{-1}$, $-30° s^{-1}$), concentric ($30° s^{-1}$, $90° s^{-1}$) and isometric knee extensors torques were evaluated by means of an isokinetic dynamometer. Traceurs showed greater ($P < .01$) drop jump performance (64.9 ± 1.5 cm) than gymnasts (60.9 ± 1.1 cm) and greater ($P < .001$) counter movement jump with arms (59.2 ± 1.5 cm) than power athletes (53.0 ± 1.4 cm). Standing long jump performances were greater ($P < .05$) for traceurs (282.7 ± 5.2 cm) compared to other athletes (gymnasts: 273.9 ± 7.3 cm; power athletes: 261.3 ± 6.7 cm). Eccentric knee extension torques were greater ($P < .05$) for traceurs compared to other athletes. This study revealed that Parkour training induces major development of jump and muscular skills. The use of such training has several practical applications as it provides a better resistance to high eccentric load and helps reinforce musculoskeletal structures.

Keywords: *Gymnastics, squat jump, drop jump, counter movement jump, standing long jump, eccentric*

Introduction

Parkour, from the French word "parcours" – meaning course, is a physical activity that was born in the suburbs of Paris at the end of the 1980s. The goal is simple: the "traceur" (Parkour practitioner) has to overcome all obstacles by means of his own physical capacities. Parkour conditioning principally involves running, jumping, climbing and quadruped movements.

Although the teaching of Parkour is still growing, it has also become a centre of interest for numerous sport teachers, personal coaches and group trainers. In fact, the particularity of Parkour lies in the specificity of the environment. For instance, traceurs use an infinite variety of obstacles, in terms of shape and/or heights. Traceurs have to use specific landing techniques after Parkour drop jumps (DJs), which can reach several meters and then represent an important eccentric effort for leg muscles (Puddle & Maulder, 2013). This specific way of training may influence the strength characteristics of traceurs. To date, very few studies have investigated how Parkour could develop force and jump skills. Most of them are related to sociological and psychological issues (Lebreton, Routier, Héas, & Bodin, 2010; Taylor, Witt, & Sugovic, 2011). Regarding physiological data, some studies have focused only on injuries caused by Parkour falls (McLean, Houshian, & Pike, 2006; Miller & Demoiny, 2008). To the best of our knowledge, only one study had investigated Parkour skills, showing that ground reactions are lower with the Parkour landing technique than with traditional landing (Puddle & Maulder, 2013).

Regarding the lack of information in the literature about physical characteristics of the traceurs, the aim of this study was to compare Parkour

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performances with others well-documented activities involving jump skills, such as gymnastic, hurdle race or triple jump. We thus assessed different vertical and horizontal jumps and knee extensors strength in eccentric, concentric and isometric contraction modes in traceurs versus power athletes and gymnasts. High plyometric exercises as well as eccentric training leads to specific gains in eccentric force (Colson, Pousson, Martin, & Van Hoecke, 1999; Wilson, Murphy, & Giorgi, 1996). Moreover, such type of training was shown to improve stretch–shortening cycle efficiency (Turner, Owings, & Schwane, 2003), increase joint stiffness and change muscle elastic properties (Kubo et al., 2007). In addition, we also provided a brief overview of the characteristics of our population of traceurs such as anthropometric, age, background and training characteristics as well as the percentage of injuries.

Due to the great eccentric component of Parkour training (e.g. landing from high jumps), we hypothesised that traceurs would develop greater eccentric torque capacity and present similar jump performances compared to other power athletes.

Methods

This study was carried out in two steps. First, data regarding training habits and anthropometric characteristics were collected by questionnaires filled out by a population of French Parkour practitioners ($n = 130$). Second, an experiment was carried out involving muscular and jump performances measurements in four smaller groups of participants ($n = 15$).

Questionnaire

A questionnaire was distributed during a national gathering of traceurs organised by the French Parkour federation (FPK). The instructions for filling out the questionnaire were given during a plenary session which took place in an amphitheatre. Participants were asked questions regarding age, anthropometric parameters, experience, characteristics and background about training. Participants were also asked to indicate other activities they practiced in addition to Parkour and to detail their background before practicing Parkour.

Muscular performances

Subjects. Experiments were performed on 60 healthy young men, subdivided into four groups: 15 power athletes (track and field; age: 22.1 ± 1.7 years, height: 1.75 ± 0.01 m, weight: 71.5 ± 1.4 kg), 15 traceurs (Parkour; age: 21.8 ± 1.3 years, height: 1.8 ± 0.02 m, weight: 69.9 ± 2.5 kg), 15 gymnasts (age: 21.4 ± 0.7 years, height: 1.75 ± 0.01 m, weight: 71.5 ± 1.4 kg), and 15 control participants (age: 23.73 ± 0.67 years, height: 1.79 ± 0.02 m, weight: 75.8 ± 2.47 kg).

Training frequency (6.4 ± 1.6 hours per week) and experience (4.5 ± 0.8 years) were similar among the three trained groups. Control participants were sedentary or recreational active with less than 2 hours of physical activity per week and with no present or prior experience in any explosive activity. Power athletes practiced disciplines such as sprint, hurdling or jumping disciplines (long, high and triple). None of the participants in the four groups reported any neurological or physical disorders. All participants were volunteers, and gave informed consent to take part in the study, after being fully informed about the investigation and possible related risks and discomfort. All participants were students at the Faculty of Sport Sciences and had medical certificate for sport activities. The study was approved by the ethics board from the Faculty and was performed in conformity with declaration of Helsinki.

Experimental procedure. All subjects performed a brief warm up of 10 minutes consisting among others of 2 minutes of in-place running, 30 seconds knee raises and calf raises. At the end of the warm up, subjects were familiarised with the several kinds of jumps by executing 5–10 submaximal jumps of each type. First, vertical and standing long jumps (SLJs) were randomly performed. Between two and five trials of each type of jump were executed, until variation in performance between the two highest jumps did not exceed 5%. The highest or longest jump was then taken for analysis. Second, isometric, concentric and eccentric knee extensors torques were randomly performed. Torques and jump performances were assessed in a single experimental session which lasted between 30 minutes and 1 hour. Particular care was taken to verify the participants' footwear. Participants were asked to wear running sneakers without flat, smooth soles. They were also asked to wear sports clothes such as shorts, light enough and not too baggy, to allow the checking of leg position.

Vertical jumps. The height of each jump was measured using a touch sensitive timing mat (model ERGO-TESTER, Globus, Italy) with the recording of suspension time and jump height directly calculated by the device. Participants were asked to jump and land with both feet at the same time, with no initial steps or shuffling. Angles of the knee and ankle were visually controlled during all landings. For reliability and safety reason, participants had to land with legs extended and to bend enough to absorb the impact. As the timing mat enables instantaneous recording as soon as the feet leave and reach the surface, we carefully controlled body position during take-off and during landing phases.

The squat jump (SJ) was assessed from a starting position with knees flexed at 90° and hands on hips, weight well distributed over both feet. Participants were asked to keep the trunk straight, and no swinging or countermovement was allowed. Even if small movements could not be detected, in the case of large uncontrolled counter movements the mat mentioned "counter movement" and the trial was not considered.

For counter movement jump (CMJ) performances, participants began in a standing upright position. Participants were asked to keep the same velocity of counter movement throughout the experiment, controlled with the timing mat. They were asked to bend to 90° knee flexion and immediately jump without pausing in the squat position. CMJs were assessed without arm movement (hands on hips) and with arm contribution. This latter, called the Abakalov jump (CMJa), is performed while swinging arms from back to front, to assist in generating maximum jump height. Participants were asked to keep a constant velocity of counter movements.

To measure DJ performance, participants were asked to drop from a height of 35 cm, corresponding to an average of 20% of participants' height. Participants were asked to drop off the box without jumping, to land on both feet similarly and then to jump immediately as high as possible. They were allowed to choose an appropriate knee angle during the landing, ranging from 90° to 70° (full extension 180°).

Standing long jumps

Participants were asked to jump as far as possible employing both feet simultaneously. The starting position was carefully controlled so that the two feet were parallel on the same line, materialised by a line on the floor. On the contrary, no ending point was indicated. No specific instructions were provided to the participants to jump far, they were free to use counter movement or arm swinging, as long as the take-off and the landing were performed with both feet similarly. The distance of the longest jump was measured as the distance between the forefoot at take-off and forefoot at landing. Marks on the floor indicated each decimetre and after landing the precise length was measured from the closest mark. The trial was cancelled if the participant fell backward.

Knee extensors strength

Muscular knee torques were assessed using an isokinetic dynamometer (Biodex Medical Systems Inc., system 3, Shirley, NY, USA). All experiments were performed in a sitting position. Measurements were recorded on the right leg with the hip angle at 90°. The participant's leg was firmly strapped to the specific accessory designed for knee movement recordings. During all experiments, particular care was taken in monitoring the participants' posture during the test. For instance, participants were asked to keep their arms crossed on the chest to avoid from grasping the chair. The trunk was stabilised by two crossover shoulder harnesses to avoid from trunk elevation during maximal contractions. The dynamometer enabled instantaneous recording of muscle torque in constant angle or at various pre-set constant angular velocities (Taylor, Sanders, Howick, & Stanley, 1991). A brief familiarisation and warm-up period of 5–10 submaximal contractions in each contraction mode (eccentric, isometric and concentric) preceded torque recordings. To assess maximal knee extension torque, participants were asked to perform at least two maximal voluntary contractions. If variations in maximal performance exceeded 5%, further trials were performed. Each maximal contraction was separated from the following one by a rest period of at least 1 minute.

For isometric measurements, the knee was fixed at an angle of 90°. For isokinetic measurements (eccentric and concentric torques), the range of motion was 120°, from 60° (knee flexion) to 180° (full extension). Angular velocities tested were: $-30°\,s^{-1}$ and $-90°\,s^{-1}$ (eccentric contraction), $0°\,s^{-1}$ (isometric contraction), $30°\,s^{-1}$ and $90°\,s^{-1}$ (concentric contraction).

Torque and angular positions were digitised online (sampling frequency 5000 Hz) and stored for analysis with Tida software (Heka Elektronik, Lambrecht/Pfalz, Germany). As the torque developed at different angular velocities is dependent on the position and angle of measure (Otis & Godbold, 1983), maximal concentric and eccentric torques were always measured at a knee angle of 90°. This allows to measure comparable performances regarding neural and mechanical changes induced by muscle stretch (Duclay, Pasquet, Martin, & Duchateau, 2011; Gerilovsky, Tsvetinov, & Trenkova, 1989).

Data analyses. The elasticity index ($EI = [(CMJ - SJ)/SJ] \times 100$), which is a reliable index of elastic tissue performance during countermovement jumps (McGuigan et al., 2006), was used to evaluate the effectiveness of the stretch–shortening cycle (Hara, Shibayama, Takeshita, Hay, & Fukashiro, 2008).

During the CMJa, arm participation index was quantified by the formula: [(CMJa – CMJ)/CMJ] × 100 (Borràs, Balius, Drobnic, & Galilea, 2011).

Statistical analyses. All data are presented as the mean ± standard deviation. The normality of the data was tested using the Shapiro–Wilk test.

Jump performances and anthropometric data (height, weight, etc.), such as EI, arm participation and SLJ performances were analysed using a one-way ANOVA (factor "group": Control, Power athletes, Gymnasts, Traceurs). To analyse vertical jump heights differences, a two-way ANOVA with repeated measures was used with the factors "type of jump" (SJ, CMJ, CMJa, DJ) and "group" (Control, Power athletes, Gymnasts, Traceurs). To analyse torque/angular velocity (T/AV) relationships, a two-way ANOVA was performed on knee extension torques, with the factors "group" (Control, Power athletes, Gymnasts, Traceurs) and "angular velocity" ($-90° s^{-1}$, $-30° s^{-1}$, $0° s^{-1}$, $30° s^{-1}$, $90° s^{-1}$).

Main effects or interactions were followed-up by Tukey's honest significant difference tests. Statistical analysis was performed using STATISTICA (8.0 version, Statsoft, Tulsa, OK, USA). The level of significance was set at $P < .05$. The effect size was calculated by the eta-squared method as recommended by Levine and Hullett (2002).

Results

Questionnaires

One hundred and thirty traceurs filled out the questionnaire: 114 men (age: 19.4 ± 4.3 years, height: 174 ± 8 cm, weight: 65.4 ± 9.1 kg) and 16 women (12.3% of the total field; age: 25.4 ± 1.9 years; height: 165.9 ± 1.7; weight: 56.6 ± 1 kg).

The population was divided into three groups according to their age: 15–19, 20–24 and 25–29 years old (Table I). The mean age of the total population was 19.4 ± 4.3 years old. The largest group was 15–20 years old for men (64.9%), and 25–29 years old (62.5%) for women. The mean total training frequency was similar among age groups for both men and women. The proportion of conditioning training tended to increase with age (Table I).

The main sport practiced by traceurs before their involvement with Parkour was martial arts (21%, see Figure 1(a)). Regarding additional sports, 53% reported no activity other than Parkour, 15% still practiced gymnastics for 3.7 ± 0.9 hours/week and 14% practiced martial arts for 3.8 ± 0.9 hours/week.

Over the total population, 48.4% did not report previous injury necessitating medical care or interruption of practice. Less than 4% reported previous serious injury requiring hospitalisation, 16.9% reported moderate injuries with medical assistance such as splints and 30.9% reported various injuries without consultation of any medical professional.

Performances

Vertical jumps. Vertical jump heights were lower for control participants than in trained groups, whatever the type of jump ($P = .001$, $\eta_P^2 = 0.89$). Control participants did not show any significant difference between SJ and CMJ or between CMJa and DJ (Figure 2(a)).

SJ height was significantly greater in gymnasts ($P = .006$, $\eta_P^2 = 0.68$) and traceurs ($P = .001$, $\eta_P^2 = 0.62$) than in power athletes. Although no inter-group differences were found for CMJ performance among trained athletes, CMJa height was greater for gymnasts ($P = .001$, $\eta_P^2 = 0.60$) and traceurs ($P = .001$, $\eta_P^2 = 0.67$) than for power athletes (Figure 2(a)). DJ performances were greater for power athletes ($P = .001$, $\eta_P^2 = 0.64$) and traceurs ($P = .008$, $\eta_P^2 = 0.65$) than for gymnasts.

The three trained groups showed a significant increase ($P = .001$, $\eta_P^2 = 0.87$) in performance among the several jumps in the following order: SJ < CMJ < CMJa < DJ, except for gymnasts who did not show a significant difference between CMJa and DJ ($P = .62$). The EI, (Figure 2(b)), was significantly greater for power athletes than traceurs ($P = .003$, $\eta_P^2 = 0.42$) and gymnasts ($P = .008$, $\eta_P^2 = 0.38$). Regarding the arm participation index (Figure 2 (b)), which quantifies the increase from CMJ to CMJa, power athletes showed a significantly lower ratio than gymnasts ($P = .025$, $\eta_P^2 = 0.37$) and traceurs ($P = .014$, $\eta_P^2 = 0.34$).

Standing long jumps. SLJ performances were lower in the control group than in the three trained groups (Figure 2(c)). Traceurs showed a better SLJ performance compared to gymnasts ($P = .038$, $\eta_P^2 = 0.85$) and power athletes ($P = .017$, $\eta_P^2 = 0.89$). SLJ performances were greater ($P = .042$, $\eta_P^2 = 0.81$) in gymnasts than in power athletes (Figure 2(c)).

Knee extensors strength. The shape of the T/AV relationship revealed different profiles among the groups (Figure 3). The control group showed lower torque for each angular velocity compared to the three trained groups. In control participants, isometric torque revealed no statistical difference with eccentric torques at $-30° s^{-1}$ ($P = .90$) or at $-90° s^{-1}$ ($P = .96$), but was significantly higher ($P < .001$, $\eta_P^2 = 0.38$) than concentric torque

Table I. Characteristics of the population, by age and sex

	Age (years)	n	Height (cm)	Weight (kg)	BMI (kg/cm^2)	Total training frequency (hours/week)	Conditioning (% total training)
Men	15–19	74	174.5 ± 0.9	63.5 ± 1	20.8 ± 0.2	8.1 ± 0.6	26.8 ± 2.1
	20–24	35	176.2 ± 1.4	68.9 ± 1.6	22.2 ± 0.3	7.9 ± 0.9	31.2 ± 3.5
	25–30	5	173.7 ± 3	67.5 ± 3	21.8 ± 0.6	5.9 ± 1	40.6 ± 3.4
	Total	114	175.6 ± 0.7	66.1 ± 0.8	21.4 ± 0.2	8.3 ± 0.5	30 ± 1.8
Women	15–19	3	172.2 ± 1	59.7 ± 0.6	20.2 ± 0.8	7.5 ± 1.6	14.9 ± 3.7
	20–24	3	179.7 ± 1.4	68.7 ± 1.8	21.3 ± 0.2	12 ± 4.2	29.4 ± 2.4
	25–30	10	172.3 ± 3.2	65.8 ± 2.8	22.2 ± 0.6	9 ± 1.63	41.4 ± 5
	Total	16	165.9 ± 0.6	56.6 ± 0.4	20.5 ± 0.1	9.23 ± 0.19	34.15 ± 1.25
Total		130	174.8 ± 0.7	65.4 ± 0.8	21.3 ± 0.2	8.08 ± 0.47	30.43 ± 1.77

BMI, body mass index.

at 30° s^{-1}. On the contrary, eccentric torques were greater than isometric torques for the three trained groups.

Traceurs, gymnasts and power athletes showed similar concentric and isometric torques. Significant inter-group differences in trained athletes were found only for eccentric torques. At −90° s^{-1}, traceurs exhibited greater torque than power athletes ($P = .012$, $\eta_P^2 = 0.56$) and gymnasts ($P = .001$, $\eta_P^2 = 0.86$). Eccentric torque was greater ($P = .009$, $\eta_P^2 = 0.94$) at −90° s^{-1} than at −30° s^{-1} in traceurs only (Figure 3).

Discussion

Our results suggest that Parkour is principally practised by men (~85%) and that ~60% of traceurs are under 20 years old. Regarding physical characteristics, traceurs attained similar CMJa heights as gymnasts and similar DJ heights as power athletes. Interestingly, traceurs had greater SLJ performances than both gymnasts and power athletes. Eccentric force capacity of the knee extensors at low and high eccentric angular velocities was greater for traceurs than for gymnasts and power athletes.

Parkour population

The mean age (~20 years) of the traceurs suggests that this activity attracts mainly young people. Parkour has indeed been reported to greatly enhance self-esteem in young adults (Cazenave & Michel, 2008). Present results also showed that traceurs have a low rate of injuries compared to other activities. For instance, gymnastics is often described as having the highest injury rate among many sports (Ehrendorfer, 1998; Maffulli, Baxter-Jones, & Grieve, 2005). Although Parkour teaching has developed quickly over the few years in France, most Parkour practitioners are self-taught. Interestingly, the group of 25–29 year-old traceurs tends to dedicate more time to physical conditioning compared to the youngest group.

Not only men practice Parkour. Indeed, women represented 12.3% of the total field. Interestingly, the greatest number of female practitioners belonged to the 25–29 year-old age group, in marked contrast to the youngest group. The rough image of Parkour, added to the fact that a large majority of traceurs are currently men, may explain younger women's reluctance to participate in the activity, whereas older women are less afraid of prejudices. The development of women's Parkour associations and specific teaching classes, in addition to the decrease in sexism in Parkour (as in sport in general), will certainly help facilitate the continued growth of women's Parkour at all levels and *in fine* encourage more women to practice Parkour.

The particular, extreme dedication of traceurs to the development of strong skills and physical capacities, in light of the fact that Parkour is not a competitive discipline, may seem difficult to understand. Interestingly, in the population studied, the most widespread discipline practiced before and while practicing Parkour was martial arts. The special connection between Parkour and martial arts may explain the vision of its practitioners: a non-competitive practice accompanied by a permanent search for self-development in new environments and through the gathering together of many traceurs all around the world. Interestingly, only very few participants reported having practiced or currently practicing explosive sports such as high or long jump, or other urban activities such as skateboarding. Instead of competition aspects, the enhancement of performances in Parkour seemed more related to the search of community approval for younger traceurs, and a personal aspiration to improve body condition in older.

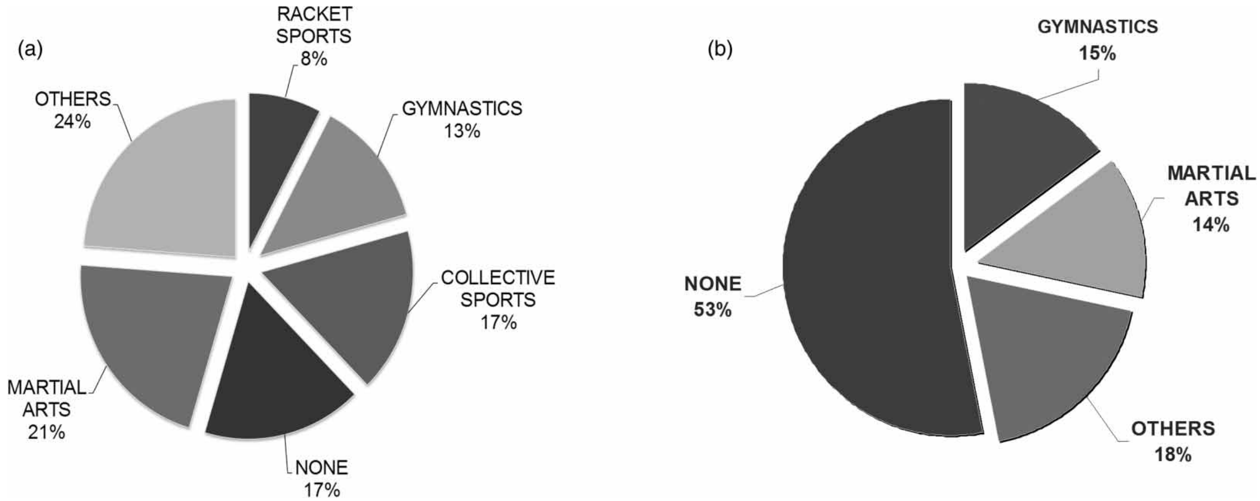

Figure 1. Sport background of the traceurs (a). Additional activity while practicing Parkour (b).

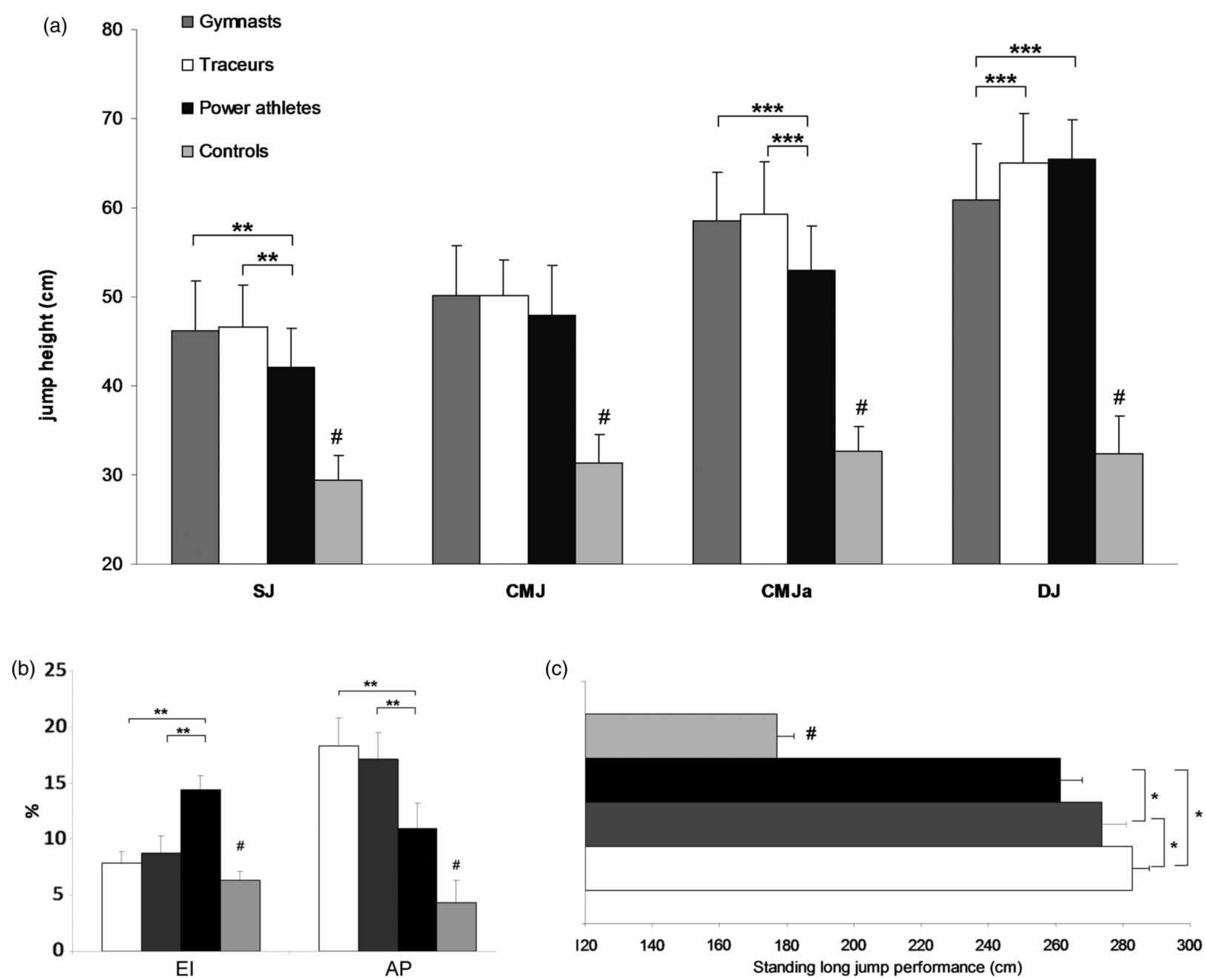

Figure 2. Jump performances of the four groups. (a) Performances in SJ, squat jump; CMJ, Counter Movement Jump; CMJa, Counter Movement Jump with arms; DJ, Drop Jump. (b) Elasticity index (EI) and arm participation (AP) in the four groups. (c) Standing long jump (SLJ) performance in the four groups. *, ** and ***: significant differences, respectively, at $P < .05$, $P < .01$ and $P < .001$. #: significantly different from the three other groups ($P < .001$).

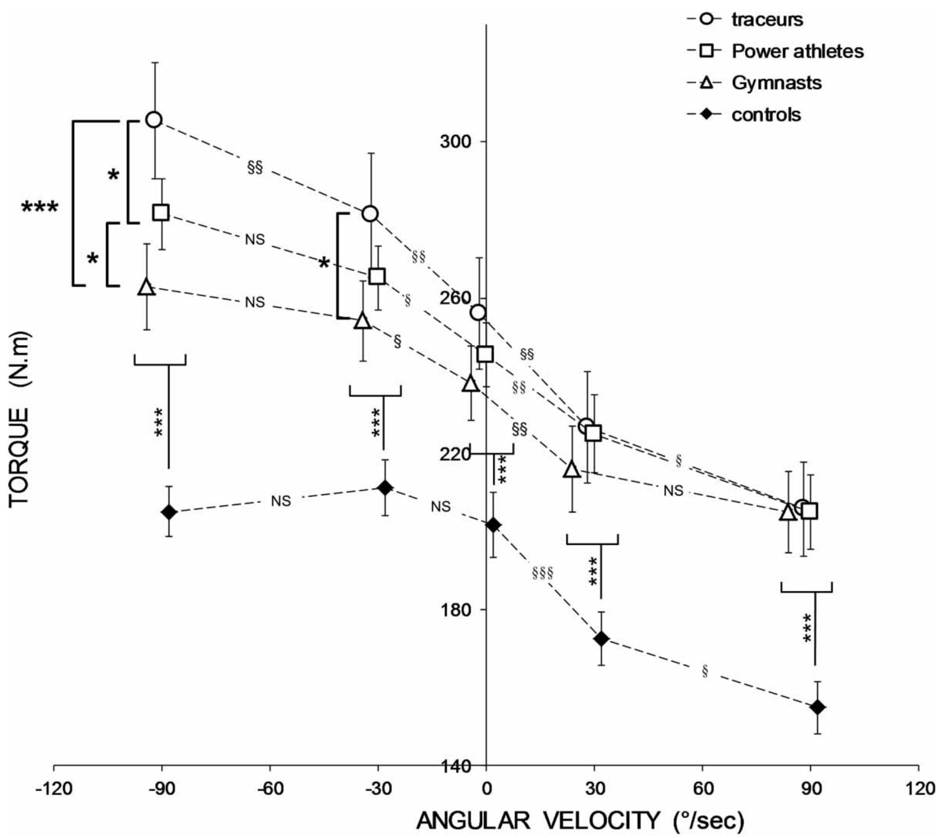

Figure 3. Torque–angular velocity relationships among the four groups. Maximal torques at all angular velocities were lower ($P < .001$) in the control group compared to other groups. *, ***: significant difference between trained groups, respectively, at $P < .05$ and $P < .001$. Non-significant differences inter-groups are not depicted to enhance the clarity of the graph. §, §§, §§: significant difference intra-groups, respectively, at $P < .05$, $P < .01$ and $P < .001$. NS, non-significant.

Vertical jump performances

Despite lower performances in SJ, power athletes showed a greater EI than traceurs and gymnasts. The specificity of training may induce different adaptations to the EI (McGuigan et al., 2006). For instance, plyometric training, widely used by power athletes, has been shown to be one of the most effective means of improving stretch–shortening cycle efficiency (Turner et al., 2003). It has been shown that eccentric training increased joint stiffness and changed muscle elastic properties (Fouré, Nordez, & Cornu, 2013). These parameters influencing CMJ height (Kubo, Kawakami, & Fukunaga, 1999) that could explain the differences observed between traceurs/gymnasts and power athletes. Plyometric training can also induce an increase in CMJ performances by reducing the transition time between the eccentric and concentric phases of the jump (Toumi, Best, Martin, F'Guyer, & Poumarat, 2004). On the contrary, the arm participation was higher in gymnasts and traceurs compared to power athletes. This result suggests a similar pattern of upper limb coordination in gymnasts and traceurs, who are both familiarised with symmetrical moves of the limbs, contrary to power athletes who usually dissociate left and right mid-body in movements. In addition, traceurs and gymnasts more frequently use vertical height in their practice, whereas power athletes are usually obliged to maintain an optimal trajectory in order to limit the rise of the centre of mass, particularly in sprints and hurdling. Upper limb coordination may play a major role in generating jump height. Generally, an increase in jump height has been widely associated with arm participation (Feltner, Fraschetti, & Crisp, 1999; Feltner, Bishop, & Perez, 2004; Lees, Vanrenterghem, & De Clercq, 2004). However, the reported importance of arm contribution varies in the literature, attributed to 28% (Lees et al., 2004) or 54% (Feltner et al., 2004) of the increased jump height, for instance. This study reported arm contributions of between 4.3% (control group) and 18.3% (traceurs) indicating that training mode can widely influence arm utilisation during jumping.

Interestingly, we found that gymnasts have lower DJ height performances than power athletes and traceurs. The use of a bouncing surface during gymnastic training could lead to a "trampoline after-effect", which decreases the stored and return energy during jumping (Márquez, Aguado, Alegre, & Férnandez-Del-Olmo, 2013). The training of power athletes and traceurs, consisting of repeated jumps on hard surfaces such as concrete, could explain differences in DJ performances with gymnasts who are more used to bouncing and flexible surfaces. In contrast to CMJ and SJ performances, DJ performances are more likely related to neuromuscular factors (Coh & Mackala, 2013), particularly to muscle pre-activation before ground contact (Avela, Santos, & Komi, 1996). The greater leg power in traceurs may not only be related to musculotendinous factors, but also to neuromuscular ones (e.g. co-activation level during DJ; Kellis, Arabatzi, & Papadopoulos, 2003).

A specialty: jumping far without run-up

SLJ performances evaluate the ability to use both upper-to-lower coordination and the stretch–shortening cycle to generate horizontal jump. The improvement in such performances can be of various natures from the starting, to the flying to the landing phases of the jump. Arm participation was attributed predominantly to an increase in take-off velocity (Ashby & Heegaard, 2002). This consideration in the case of SLJ compared to vertical jump assessment suggest that arm participation is preponderant in increasing performance, which may explain differences between traceurs/gymnasts and power athletes. Regarding kinematic parameters, it has been shown that the take-off angle for the standing long jump should be minimised as the optimal angle is known to be less than 45° (19–27°) (Wakai & Linthorne, 2005). It should be noted that traceurs are very likely to be familiar with low take-off angles. In general, the SLJ is a standard move in Parkour, whereas athletes or gymnasts are more familiar with run-up jumps. This may partly explain Parkour practitioners' better performances in SLJ compared to other trained groups, traceurs having more skills to perform this technique.

Parkour: a massive eccentric training mode

At eccentric velocities, it was shown that the torque may decrease or reach a plateau in low strength participants and increase in highly trained participants (Hortobágyi & Katch, 1990). The shape of the torque/angular velocity (T/AV) relationship is also influenced by individual strength level (Westing & Seger, 1989). For instance, it was found that the T/AV curve is steeper in high-strength participants (Hortobágyi & Katch, 1990), with a specificity in gains according to the contraction velocity used during training (Caiozzo, Perrine, & Edgerton, 1981). Eccentric torques did not increase in the control group compared to isometric torques, suggesting that the training of power athletes, gymnasts and traceurs may induce specific gains in eccentric contractions. Indeed, it is known that plyometric training increases eccentric force (Wilson et al., 1996).

It has been shown that eccentric training increased maximal torque specifically at eccentric velocities (Colson et al., 1999), modifying significantly the shape of the T/AV relationship (Hortobágyi & Katch, 1990; Westing & Seger, 1989). Eccentric torque values were greater in traceurs than in power athletes and greater in power athletes than in gymnasts. It should be pointed out that different training surfaces among the three activities could induce different muscle adaptations, as the work load is, for instance, minimised on the flexible surface used in gymnastic training (Márquez et al., 2013). One of the main landing techniques in Parkour, in the case of a vertical fall from a certain height, is to maximise the ankle, knee and hip flexion to absorb the weight impact. This technique was found to be safer than the traditional landing technique, as it reduces vertical load (Puddle & Maulder, 2013). The repetition of such jump heights in traceurs' training represents an important eccentric load and may explain the greater eccentric torque capacity in knee extension for traceurs. Plyometric exercises added to massive eccentric contractions in Parkour could lead to a significant gain in eccentric force and jump performances (Santos & Janeira, 2008), whereas track and field training consists mostly of plyometric exercises. Neuromuscular adaptations to parkour training can lead to such performances. For instance, it was shown that highly skilled subjects showed greater agonist activation during eccentric contraction than untrained subjects and a lower co-activation at all angular velocities (Amiridis et al., 1996). Eccentric contraction involves a specific neural control compared to concentric and isometric ones (Duchateau & Enoka, 2008; Grosprêtre, Papaxanthis, & Martin, 2014). Thus, several factors could explain better eccentric performances in traceurs, such as greater musculotendinous stiffness or neuromuscular adaptations.

Conclusion

Who then is the traceur? The traceur is a male, quite young (<25 years); he trains for 6–8 hours per week in various environments and develops advanced jumping abilities. Regarding physical characteristics, the present results suggest that traceurs had high plyometric abilities and great upper-to-lower limb coordination, leading to better performances in standing long jumps. Further investigations are needed to evaluate the specificities of jump traceurs characteristics such as kinetics and kinematic parameters (take-off velocities, trajectories and joint angles). The greatest eccentric torque capacity for knee extensors in the group of traceurs may be attributed to the high eccentric loads supported during their training. Such high-impact training is more, and more considered for increasing athletes' strength or reducing harmful effects of sedentarily, since it provides great muscular development and helps preventing bone impairments (Tobias et al., 2014). We hope that this study will stimulate further research to investigate the physiological characteristics of traceurs.

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Disclosures

No potential conflicts of interest was reported by the authors.

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