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SPORTS & EXERCISE | RESEARCH ARTICLE

Self-reported injuries of competitive US figure skaters

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Abstract: The majority of figure skaters are young females competing in local and regional competitions. There is little information describing injuries in this population of skaters. The purpose of this study was to describe injury characteristics and training habits of Non-Qualifying (NQ) and Qualifying (Q) competitive figure skaters and to compare their injury characteristics and training habits to Nationally or Internationally (NI) competitive figure skaters. 474 figure skaters completed the survey. 204 of these skaters met the criteria as currently competitive figure skaters participating in NQ, Q, or NI events. NQ skaters trained half as many hours per week (6.3 h/w) as compared to Q (12.3 h/w) and NI (13.7 h/w). There were 152 reported injuries across all groups. Acute injuries were more commonly reported than overuse injuries with ratios of 2.1:1 for NQ skaters; 1.3:1 for Q, and 1.4:1 for NI. Ankle sprains were the most common injury accounting for 11% of all injuries followed by concussion at 7%. Fractures/Stress fractures and concussions were more common in NI (17.6%, 11.7%) and Q (20.8%, 7.6%) than in NQ (12.4%, 2.15) skaters. NQ skaters predominantly reported acute injuries. Q and NI skaters have similar injury profiles to each other with more overuse injuries than NQ. Coaches and sports medical professionals need to be aware that skaters participating in qualifying competitions train similar hours and demonstrate similar injury patterns to elite skaters. While

ABOUT THE AUTHORS

The authors are interested in sport injury and injury risk factors. Research areas of the authors are varied and topics include biomechanics of movement skills related to lower extremity injury, impact forces and loading of the lower extremity in sport and psychical activity, pediatric sports medicine, gender differences in non-contact ACL injuries, and endurance athlete sport performance. A common interest of the authors is health and performance of young figure skating athletes. The research work in this paper addresses an under-represented group of figure skaters in the current scientific literature: competitive skaters participating at local and regional shows and competitions. Specifically we are interested in injury and training characteristics of this group of skaters in comparison to elite figure skaters participating at the national and international levels.

PUBLIC INTEREST STATEMENT

Injuries are common in elite figure skating. These elite skaters often skate 11 months of the year, 2 to 6 h a day performing 50 to 100 jumps a day. Elite skaters are only a small percentage of the skating population in the US. Most figure skaters are young girls/adolescents skating in club, local, and regional shows and events. We studied the skating habits and injury characteristics of these young local/regional skaters. Ankle sprains were the most common injury reported by all levels of skaters in our study, followed closely by concussions. Younger less competitive skaters had more acute injuries than the older more competitive skaters did. Skaters competing in qualifying competitions at the regional level had similar training and injury patterns to national/international level skaters. Health professionals, coaches, and exercise professionals should be aware of the demands of and risks to non-elite skaters to optimize training, equipment, and rehabilitation strategies to keep skaters healthy and safely return them to skating.

overuse injuries are more common in these skaters as compared to NQ skaters, acute injuries, particularly ankle sprains and concussions, dominate.

Subjects: Applied Sport Science; Sports Injury; Sports Medicine; Sports Rehabilitation; Sports Medicine; Physiotherapy

Keywords: ice skating; sports injuries; ankle sprains; concussions

1. Introduction

Competitive figure skating may conjure images of Olympic athletes completing intricate spins, jumps, and throws. However, very few figure skaters compete on the international stage. According to US Figure Skating (USFS), of the over 178,000 members, only 90 athletes were selected as US team skaters to represent the USA at International competitions (US Figure Skating, 2015). USFS members can compete in non-qualifying events, USFS sanctioned competitions that do not lead towards qualifying for national championships, and qualifying events such as regional or sectional championships, which may lead towards qualifying for national championships in one of three disciplines: singles, pairs, and dance. Singles skating is done as an individual, pairs involves a male and female partner with throws, lifts, and jumps, while dance involves a male and female partner focusing on footwork and skating in ballroom dance holds.

Figure skating is not without risks; though ice-skating as a recreational activity has a low incident rate for injuries (Bernard et al., 1988; Freeland, 1988; Oakland, 1990; Radford, Williamson, & Lowdon, 1988; Williamson & Lowdon, 1986). Emergency room studies of injured ice skaters from local ice rinks indicate that injuries tend to occur in inexperienced skaters and involve falling or being cut by a blade with a predominance of injuries occurring to the upper extremities (Bernard et al., 1988; Freeland, 1988; Oakland, 1990; Radford et al., 1988; Williamson & Lowdon, 1986). Most injuries are relatively minor and involve only a small fraction of public (recreational) ice skaters (Bernard et al., 1988; Freeland, 1988; Oakland, 1990; Radford et al., 1988; Williamson & Lowdon, 1986). Fifty-six percent of those evaluated were beginner skaters who had skated less than 10 times. Moreover, beginner ice skaters had more serious injuries than intermediate or experienced ice skaters (Radford et al., 1988).

In contrast to the low incidence of injuries of public ice skaters, during the course of their careers, 75% of nationally and internationally competitive figure skaters report injuries (Brock & Striowski, 1986; Dubravcic-Simunjak, Pecina, Kuipers, Moran, & Haspl, 2003). In a small prospective study, 75% of participating skaters presented with injuries resulting in missed ice time over the course of one season (Kjaer & Larsson, 1992). Of these injuries, between 25 and 50% of reported injuries were acute and 50% were overuse injuries (Brock & Striowski, 1986; Dubravcic-Simunjak et al., 2003; Kjaer & Larsson, 1992; Lipetz & Kruse, 2000).

For competitive singles figure skaters, specifically, the most common injuries are stress fractures, jumper's knee, and shin splints (Dubravcic-Simunjak et al., 2003). Stress fractures occur most frequently in the foot and lower leg (Dubravcic-Simunjak et al., 2003; Kjaer & Larsson, 1992). Researchers have postulated that the repetitive motions of jumping and landing contribute to these common overuse injuries as figure skaters at this level train both on and off the ice for two to eight hours per day, up to six days per week (Dubravcic-Simunjak et al., 2003; Pećina, Bojanić, & Dubravčić, 1990).

Figure skaters in pairs and dance events report more ankle sprains, head injuries, and lacerations than singles skaters (Dubravcic-Simunjak et al., 2003; Fortin & Roberts, 2003). In both pairs and dance, a male and female figure skater are skating in close proximity to each other performing intricate footwork, complex spins and twirls, and lifting of the female skater. In pairs skating, the female is thrown into the air where she completes one to three revolutions before being caught or landing on one foot on the ice. These complex skills performed hand in hand with a partner in addition to the lifts and throws are likely related to the higher number of acute injuries reported in these two

disciplines. Low back pain, however, is common across all three disciplines, singles, pairs, and dance, ranging from 8 to 13% (Dubravcic-Simunjak et al., 2003).

Adult figure skaters, aged 26 and older, also report a high incidence of injuries, with over 50% of adult skaters reporting at least one injury over the previous year in a recent study (Ferrara & Hollingsworth, 2007). Adult skaters make up only 15% of USFS membership with the majority of US figure skating members between the ages of 7 to 12 years old (35%) (US Figure Skating, 2015). Moreover, many of the figure skaters who participate in USFS Figure Skating clubs join for the social aspect of skating, physical fitness, performance and artistic expression, and not just to compete at the club, regional or sectional level. These younger skaters are not well represented in the scientific literature. It is not known how injuries in these skaters compare to that of the nationally and internationally competitive figure skaters. It is unlikely that injury rates and types of injuries would mimic those of the public / recreational ice skaters or national and international figure skaters. Knowing the types of injuries incurred by figure skaters in the USA who participate in club events, shows and non-qualifying competitions, and knowing the relationship of these injuries to training and skating habits is an important first step to developing prevention programs for this large but underrepresented group of skaters. Thus, the purpose of this study is to determine injury characteristics and skating and training habits of USA figure skaters participating in all levels of the sport. It is anticipated that results will provide the medical and skating communities with information to improve understanding of the types of injuries and training of figure skaters and that this knowledge will be an impetus to future research to develop evidence based injury prevention and return to “skate” strategies for figure skaters of all levels.

2. Materials and methods

The project was approved by the Institutional Human Subjects Review Board and informed consent was obtained from participants or legal guardians. A Skater Injury and Prevention Survey (SkIPS) was created to evaluate figure skating injuries and possible contributing factors. SkIPS was distributed via paper, email, and Facebook. Paper surveys were distributed at five 2011 United States Figure Skating (USFS) Standardized Testing of Athleticism to Recognize Skaters (STARS) programs (388 total participants) and at the 2011 USFS High Performance Camp (23 participants). Social media and email were used to distribute links to the electronic survey to figure skaters and coaches. Links were distributed via the Professional Skating Association (PSA), who has 5,670 members, USFS clubs with email or Facebook pages (370 clubs), and all intercollegiate clubs (74). Recipients were encouraged to forward the online link to other skaters. The total number of skaters who received the link via these social media outlets is unknown. Respondents were asked, but not required, to provide contact information for follow up questioning, if necessary, for clarification of survey responses. Of 474 returned surveys, 263 respondents provided contact information. Researchers contacted 156 of these 263 respondents by phone or email to obtain additional information regarding their survey responses.

SkIPS consisted of 77 questions in 6 main categories: (1) skater demographics, (2) skating history and level, (3) on ice practice habits, (4) off ice training, (5) non skating competitive and recreational sports and activities, and (6) injury history. Acute injuries were defined as a sudden onset of pain that may occur from a traumatic event. Overuse injuries were defined as injuries developing gradually without a clear cause or traumatic event. Injury history referred to injuries over the course of their career. Injury dates and diagnoses determined by a medical professional were requested for each reported injury.

Skaters were asked their highest USFS moves-in-field test level to assess skill level. There are eight moves-in-field levels: 1, the lowest, is pre-preliminary and 8, the highest, is senior. Parents or guardians were asked to fill out the survey with their child/ward, if, as judged by the parent/guardian, the child/ward was too young to complete the survey independently.

Skaters under the age of 40, determined by the oldest NI skater, who completed the skater demographics, skating history and level, on ice practice habits, and injury history categories, and who were currently participating in skating events and competitions were included in the study. These skaters were then split into three groups: skaters who had not competed in a qualifying competition (NQ), those who had competed in qualifying competitions below the national level (Q), and skaters who had competed at national and international competitions (NI). Frequency tables were created for all items in the survey. Data analysis was completed in SPSS (version 22.0, IMB Corp, New York).

3. Results

Four hundred and seventy-four (474) figure skaters returned the survey and 204 met the inclusion criteria. 90% were female and 10% male. The average age was 18.7 ± 6.4 years old (range: 7–38 y) with similar age ranges in each of the three groups: NQ, Q, and NI (Table 1). The majority of skaters participated in singles skating (91%). 73 skaters were classified as NQ, 71 were Q, and 60 were NI (Table 1). Skaters in the NQ and Q groups participated predominantly in singles with 4% and 6%, respectively, participating in pairs, and 20% or less in dance (Table 1). 78% of NI participated in singles, 25% pairs, and 43% dance. 34% of all skaters reported participating in more than one discipline. Within the NQ group, the moves-in-field highest testing level with the most number of skaters was level 5-intermediate. 10% of NQ skaters had passed their senior moves-in-field test. 32% of Q and 64% of NI skaters had passed their senior moves-in-field test which was the testing level with the highest number of Q and NI skaters (Table 1). NQ skaters skated nearly half as many hours per week in-season as compared to both Q and NI (Table 1).

3.1. Types of injuries

One hundred and fifty-two (152) injuries were reported (Table 2). For NQ skaters, nearly twice as many skaters reported acute vs. overuse injuries, while for Q and NI the ratio was between 1.3 and 1.4 acute to overuse injuries respectively. Sprains (20%) were the most commonly reported injury for all groups (Table 2). Muscles strains were also common at 14% of all injuries. The percent of NQ skaters reporting a strain (22%) was almost twice as high as the percent of Q and NI skaters that reported strains (12% each). The other most frequently reported injuries were: fractures (11%), concussions (7%), and stress fractures (7%) (Table 2).

3.2. Sites of injuries

For NQ (Column 1) and Q (Column 2) skaters, the ankle (18% and 20%) was the most frequently reported injured body part followed by the knee (12% and 18%) and foot (10% and 11%). 11% of Q skaters reported low back injuries. 18% of NI skaters (Column 3) reported knee injuries, followed by foot (13%), ankle (13%), low back (13%) and face (13%). All other injured body parts were reported by less than 10% of the respondents.

Table 1. Summary of skater characteristics in each group. Age and hours/week are mean \pm SD

	NQ	Q	NI
Female	71 (97%)	65 (92%)	47 (78%)
Male	2 (3%)	6 (8%)	13 (22%)
Age (y)	16.6 ± 6.1	17.4 ± 5.6	22.9 ± 5.6
Range	7–37	7–38	12–37
Singles	70 (96%)	66 (93%)	50 (83%)
Pairs	3 (4%)	4 (6%)	15 (25%)
Dance	15 (21%)	12 (17%)	26 (43%)
Senior moves-in-field	7 (10%)	23 (32%)	38 (64%)
Hours/week (in season)	6.3 ± 3.4	12.3 ± 5.6	13.7 ± 6.3

Table 2. Injuries by type reported by skaters in all 3 groups

	NQ	Q	NI
Total injuries	48	53	51
Acute	31 (64.6%)	29 (54.7%)	28 (54.9%)
Overuse	15 (31.3%)	21 (39.6%)	22 (43.1%)
By Type			
Sprain	8 (16.7%)	12 (22.6%)	10 (19.6%)
Strain	8 (16.7%)	7 (13.2%)	6 (11.8%)
Fracture	3 (6.3%)	8 (15.1%)	5 (9.8%)
Stress fracture	3 (6.3%)	3 (5.7%)	4 (7.8%)
Concussion	1 (2.1%)	4 (7.6%)	6 (11.7%)

Note: Percent is calculated as percent of total injuries reported within each group.

Table 3. Specific injuries within and across groups. Only injuries reported more than 5 times (across all groups) are included

	NQ	Q	NI	Total
Ankle sprain	5	8	3	16
Concussion	1	4	6	11
Foot fracture/stress fracture	1/0	2/1	3/1	6/2
Knee sprain	1	2	5	8
Low back fracture/stress fracture	0/1	0/1	0/3	0/5
Shin fracture/stress fracture	0/2	2/1	0/0	2/3

Note: Percent is calculated as percent of total injuries reported within each group.

3.3. Most common specific injuries

The most commonly reported injury to the ankle was a sprain for all groups. Sprains accounted for 43% of reported ankle injuries for NI, 63% for NQ and 73% for Q. The types of knee injuries reported were varied, ranging from sprains (NQ, Q, and NI) and contusions (NQ, Q) to tendonitis (Q and NI) and Osgood-Schlatter’s Disease (Q and NI). Low back injuries were reported by skaters in all groups with stress fractures being the mostly commonly reported low back diagnosis when combining all groups together. The most commonly reported specific injuries were ankle sprains (11% of total injuries), concussions (7%), knee sprains (5%), and foot fractures/stress fractures (5%) (Table 3).

4. Discussion

We surveyed USA figure skaters from a broad range of levels. Previously, there have been studies looking at injuries sustained with public /recreational skaters at ice rinks and elite level figure skaters with a paucity of data on figure skaters competing at lower levels or only in non-qualifying competitions. Our study revealed within group similarities as well as differences in different levels of competitive skaters and identified distinct injury patterns that have not been previously recognized with figure skaters.

All three groups of skaters reported more acute injuries than overuse injuries. Nationally and internationally competitive singles figure skaters report more overuse injuries than acute injuries (Brock & Striowski, 1986; Dubravac-Simunjak et al., 2003; Fortin & Roberts, 2003; Kjaer & Larsson, 1992; Lipetz & Kruse, 2000; Porter, 2013); our NI skaters, however, were a combination of pair, dance, and singles skaters. The NQ skaters in particular reported nearly twice as many acute injuries as opposed to overuse injuries. In addition to a lower training volume, NQ skaters learn new skills as they move through the ranks, which may predispose them to acute injuries. The Q and NI skaters reported similar patterns of acute and overuse injuries.

The Q skaters, though younger and less skilled than NI skaters, were skating at a similar volume as the NI skaters, perhaps leading to the increased percent of overuse injuries. According to the literature, acute injuries are more commonly observed in public skating (Bernard et al., 1988; Freeland, 1988; Oakland, 1990; Radford et al., 1988; Williamson & Lowdon, 1986) and in elite pairs skating (Brock & Striowski, 1986; Dubravcic-Simunjak et al., 2003; Fortin & Roberts, 2003; Smith & Ludington, 1989). Given the nature of pair skating which includes lifts, throws and side-by-side spins this finding is not surprising and may account for the larger number of acute injuries observed in that discipline (Brock & Striowski, 1986; Dubravcic-Simunjak et al., 2003; Fortin & Roberts, 2003; Smith & Ludington, 1989). The most common overuse injuries, tendonitis and Osgood-Schlatter's, were a common theme for the skaters in this study and are supported by the previous findings. These injuries are not surprising given the nature of the sport, including a high volume of jumping, landing, intricate foot-work, and spins.

Supporting the literature, the most common injury site in our study, regardless of skating level, was at the ankle (Dubravcic-Simunjak et al., 2003; Fortin & Roberts, 2003). The next most common injury sites, the knee and foot, also support previous literature that figure skaters report the most injuries to the lower extremity (Brock & Striowski, 1986; Campanelli, Piscitelli, Verardi, Maillard, & Sbarbati, 2015; Dubravcic-Simunjak et al., 2003; Fortin & Roberts, 2003; Kjaer & Larsson, 1992; Porter, Young, Niedfeldt, & Gottschlich, 2007). The number of skaters reporting injuries to the lower extremity, in terms of percentage, is fairly similar for both NQ and Q skaters despite the large discrepancy in hours of training and different level of skating. Nearly one third of Q skaters had passed their senior moves in field while only 10% of NQ skaters had achieved the same level. Additionally, the Q skaters were training at a volume nearly twice that of the NQ skaters. NI skaters reported more knee injuries than ankle or foot, as compared to NQ and Q; though lower extremity injuries were still the most commonly reported injury. An increase in NI knee injuries could be related to both a higher overall training volume, complexity of their skills, and an increased repertoire of jumps to train.

Q and NI skaters, also reported more low back, head, and face injuries than NQ. Low back pain has been observed at similar percentages in national and junior elite skaters (Dubravcic-Simunjak et al., 2003). NQ skaters, as compared to Q and NI, may be reporting lower numbers of low back injuries due to a lower training volume or skill level. These skaters may not yet be performing skills or skating with the duration or intensity that may be associated with low back pain in skating. Future research is certainly warranted to determine if factors related to the development of low back pain and other specific injuries in more highly rated skaters are due to hours training, the high-level skills being performed, strength and conditioning of the athletes, age, or some yet to be determined factors.

Ankle sprains were the most common injury reported in our skaters which is consistent with other studies (Dubravcic-Simunjak et al., 2003; Fortin & Roberts, 2003; Kjaer & Larsson, 1992). The varied skills such as stroking, spinning, gliding, and landing, all occurring on a narrow base of support, require incredible stability at the ankle joint and may contribute to the reported ankle injuries. This finding is interesting as the skating boot is specifically designed to offer medial-lateral support to the ankle joint through its lateral rigidity. It is not uncommon for elite skaters to utilize two to three different pairs of skates during the year, rotating them as each are at different stages of deterioration. It can be theorized that ill-fitting boots, deteriorated boots, or loose lacing could contribute to ankle sprains; though, research is needed to determine if there is an association with boot wear and ankle injuries.

Based on the results, it is clear that the ankle is susceptible to acute injury in figure skating. Developing effective preventative programs needs to be a priority for the sports medicine skating community. Prophylaxis interventions consisting of external ankle support or neuromuscular training reduces the risk of ankle sprain in court and field sport athletes, generally being more effective for preventing recurring ankle sprains as opposed to first time sprains (Taylor, Ford, Nguyen, Terry, & Hegedus, 2015; Verhagen et al., 2004a; Verhagen et al., 2004b). However, there have been no studies looking at prevention of ankle injuries in skaters; it is worth investigating if balance training and or external support would lower the incidence of ankle injuries in skaters. Specifically working on

proprioception while in the skate might enhance the benefit. It would also be worthwhile investigating boot design and fit in relation to ankle injury. If boot design and fit are related to ankle injury in figure skaters, developing evidenced based boot prescription guidelines could be an effective strategy for reducing ankle injuries in figure skating.

Concussions were the second most commonly reported injury. It was not surprising that concussion numbers were high in Q and NI groups since these skaters are performing complicated skills, such as higher revolution jumps, at higher speeds. The relative risk of falling may be higher in ice dancers and pairs due to throws and lifts and these disciplines were represented more in our Q and NI groups.

As concussion awareness has increased over recent years, there has been a steady increase in concussion reporting (Lincoln et al., 2011). Thus, skaters recalling past injuries might have had concussions left undiagnosed and thus not reported in this study, potentially underestimating the true number of concussions. Concussions have been reduced in skiing and snowboarding, though not other sports, through the use of helmets (Cusimano & Kwok, 2010a, 2010b; McCrory et al., 2013). While helmets are often not initially welcomed by athletes due to change, it may be reasonable for figure skaters to consider the use of helmets for on-ice training when the relative risk for falling might be high such as learning new lifts and throws.

4.1. Limitations

Recall bias is a limitation for all retrospective surveys. Moreover, the culture of figure skating tends to ignore and skate through injuries, so some skaters may not think of some pain as an injury and it would go unreported. We tried to limit recall bias by contacting those skaters, who were agreeable to it, with follow-up email and phone calls. However, 83% of injuries sustained over 1 year period were accurately recalled by a group of Danish figure skaters (Kjaer & Larsson, 1992) lending support to the appropriateness and validity of injury surveys for characterizing injuries in the figure skating population. Injury recall of non-elite skaters, however, has not been validated. The diagnosis of each injury made by a medical professional, if available, was obtained. Parents/guardians completed the survey with minors in effort to obtain reliable diagnoses from the young skaters included in the study. However, the reliability of parent/guardian recall as opposed to athlete recall is an unknown.

Another factor affecting injury reporting via survey can be people tending to link pain to a previous event or trauma and often neglecting to consider the cumulative load from overtraining as a possible etiology. A skater may have classified pain from a stress fracture as acute because there was one loading episode that brought the pain to her awareness despite the fact that the bone was already cumulatively overloaded. As a result, there could be an increase in reporting acute injuries that are actually overuse injuries. Finally, as with all self-report injury surveys, the skater can only report the information provided to them by the treating clinician. Without a physical exam performed by the same sports medical team, we cannot ensure that all injuries were diagnosed accurately.

Due to the nature of our injury study, it is not possible to determine exposure hours for the skaters in this study. Thus, a major limitation is the inability to calculate injury rates or injury risk as defined by incidence rate. Determining injury rate and risk is an important next step for understanding injuries in different levels of competitive figure skating and warrants further research. However, identifying the types of injuries sustained by different levels of skaters, as was done in this study, is important and provides valuable information to coaches and sports medicine professionals. We also did not ask skaters to report injuries in practice vs. competition, which could have different recall biases. We did collect data on when the injury occurred, “pre-season”, “in-season”, or “off-season”; though, these data were not analyzed for this study.

Lastly, our skaters tended to be older than the predominant age group of USA figure skaters. It is likely that the dearth of younger skaters is due to our sampling procedures, which included collecting surveys at the STARS and high performance camps, contacting USFS figure skating clubs, and PSA

members. To truly represent the vast majority of USA figure skating active skaters and determine injury rates and risks, collecting data in person at club skating sessions and prospectively tracking skater injuries and exposure hours may be required.

5. Conclusions

We queried USA figure skaters of various levels for injuries and training. We found similar injury types across different levels of skaters. Acute injuries were greater than overuse injuries across all groups; though the non-qualifying skaters had a greater percent of acute injuries as compared to qualifying, national, and internationally competitive skaters. Despite the physical constraints of a figure skating boot, figure skaters at all levels reported ankle sprains most frequently, which should perhaps be expected given the biomechanical nature and balance demands of the sport. Concussions were the second most highly reported injury with greater numbers with increased competition level. Skating coaches, strength and conditioning specialists, parents, and sports medical professionals need to be aware that acute injuries particularly, ankle sprains and concussions, are common for all skaters despite skating level or training hours. Skaters who participate in and train for qualifying competitions, train similar hours and demonstrate similar injury patterns to elite skaters participating in National and International events, and these skaters report similar overuse injuries as their NI counterparts. As skater's progress to the qualifying level, care should be taken when prescribing training regimens to allow the skaters to attain essential skills while increasing their strength and flexibility and allowing appropriate rest and recovery.

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Competing Interests

The authors declare no competing interest.

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