Spinal Cord (2007) 45, 513–517

www.nature.com/sc

Original Article

The incidence of post-race symptoms of upper respiratory tract infection in wheelchair marathon racers

K Furusawa*[,1], F Tajima[2], H Okawa[3], M Takahashi[4] and H Ogata[4]

[1]*Kibikogen Rehabilitation Center for Employment Injuries, Kaga-gun, Okayama, Japan;* [2]*Department of Rehabilitation Medicine, Wakayama Medical University, Wakayama-shi, Japan;* [3]*Department of Physical Therapy, Seijyo University, Tokai-shi, Japan;* [4]*Department of Rehabilitation Medicine, School of Medicine, University of Occupational and Environmental Health, Yahatanishi-ku, Kitakyushu, Japan*

Study design: Prospective analysis.
Objectives: To investigate the influence of exercise and major competition on infectious episodes in athletes with spinal cord injuries (SCI).
Setting: Japan.
Methods: We examined the self-reported infectious episodes of upper respiratory tract infection (URTI) in athletes with SCI during a 1-month period before the race and 2 weeks after the race. The study included 21 persons with SCI who participated in the 18th Oita International Wheelchair Marathon. Thirteen persons with SCI who did not participate in the race were studied as control subjects.
Results: The number of URTI episodes in marathoners was 0.086 ± 0.036/week during the 1-month period before the race and 0.089 ± 0.040/week during the 2-week post-race period, whereas that of the controls was 0.139 ± 0.046/week during the 1-month period before the race and 0.072 ± 0.047/week during the 2-week post-race period. There were no significant differences between before and after the race in marathoners, or between marathoners and controls during each period. However, the number of URTI episodes 2 weeks after the race was significantly higher in subjects who trained more than 65 km/week compared to those who trained less than 65 km/week.
Conclusions: In subjects with SCI who completed a wheelchair full marathon race, the incidence of URTI after the race was not high compared to control subjects who did not participate in the race. According to the number of URTI episodes and the training data, it is recommended that wheelchair marathoners should consider their risk for URTI during excessive practice.
Spinal Cord (2007) **45,** 513–517; doi:10.1038/sj.sc.3102028; published online 6 February 2007

Keywords: wheelchair marathon; spinal cord injury; immune response

Introduction

There are about 120 million persons living in Japan. Annually, about 1000 persons suffer from spinal cord injuries (SCI) during work.[1] Most of them perform well in rehabilitation programs and develop the ability to take part in their home lives and social communities.[2,3] Sports and exercise are highly recommended for persons with SCI, as physical activities required in daily living are not sufficient to maintain physical fitness after a medical rehabilitation program.[2,3] However, there is a general perception among marathon racers, coaches and sports physicians that athletes are susceptible to infections during intensive training and major competitions.[4] Several epidemiological reports have suggested that able-bodied athletes engaging in marathon-type events and/or very heavy training are at an increased risk of upper respiratory tract infection (URTI).[5] URTI is the most common infection in highly trained athletes.[6] Furthermore, the risk of URTI in able-bodied athletes appears to be especially high during the 1- or 2-week period following marathon-type race events.[5]

The wheelchair marathon race is one of the most difficult wheelchair sports, but it is a symbolic challenge for disabled persons and a well-organized event worldwide. We previously observed that in competitive

*Correspondence: K Furusawa, Kibikogen Rehabilitation Center for Employment Injuries, 7511 Yoshikawa, Kaga-gun, Kibichuo-cho, Okayama 716-1241, Japan

wheelchair racers with T5-L1 SCI, peripheral natural killer (NK) cells and natural killer cell cytotoxic activity (NKCA) decreased immediately after a wheelchair full marathon and recovered to base line values after just one night of rest.[7] On the other hand, NKCA was shown to increase significantly immediately after a wheelchair half marathon and remain increased during the next day in disabled recreational athletes with T7-L1 SCI.[8] We considered that the decrease of NK cell function immediately after a wheelchair full marathon race might be due to this activity's characteristics as a prolonged and intensive exercise. Athletes with paraplegia undertaking extreme exercise may therefore be advised to take extra precautions within 24 h of such a stress to increase host defense from bacterial and viral infections.

Persons with SCI commonly develop infections of the urinary tract, respiratory tract and skin, indicating that such patients may have diminished host defense mechanisms.[9] However, there have been no studies designed to consider the effects of wheelchair competition on the incidence of URTI. The purpose of this study was to investigate the effects of exercise on infectious episodes in athletes with SCI. We examined the self-reported episodes of URTI in competitive wheelchair racers with SCI during a 1-month period before a race and 2 weeks after the race.

Materials and methods

A questionnaire was sent to applicants of the 18th Oita International Wheelchair Marathon, which is one of the most recognized races in the world, held on 1 November 1998, in Oita, Japan 2 months before the race. The questionnaire included questions on demographic data, training habits and incidence of illness for the 1-month time period before the race and the 2-week post-race period. Wheelchair marathon racers were asked to self-report daily running distance and the intensity of their exercise using Borg's scale. They were also asked to self-report whether they had been sick with a cold, flu, sore throat, cough, fever, runny nose or sneezing during the time periods indicated. An episode of URTI was defined as having commenced when subjects recorded any of the above symptoms (sore throat, cough, fever, runny nose, sneezing) for more than 2 days and separated by at least 1 week from a previous episode.[10] When their physicians diagnosed allergic manifestations, these symptoms were excluded. Control subjects with SCI who did not have a habit of exercising and did not participate in the wheelchair marathon race were asked to self-report the same symptoms during the same time to exclude the possible influence of seasonal changes on the incidence of URTI.

The anthropometric characteristics of athletes were examined on the race registration day (the day before the race), and those of control subjects were examined at our hospitals. All the subjects in this study had no current health problems except for SCI and were taking no medications that would affect their immune and endocrine response. The subjects were analyzed according to their wheelchair race intensity, time and distance in training.

Informed written consent was obtained from all participants in the study. The protocol of this study was approved in advance by the Human Research Committee of Oita International Wheelchair Marathon Organization (OIWMO). The official race results of all participants (time and position) were detected by OIWMO, and we used the published official results as our subjects' race times.

Statistical analysis

Data were expressed as means ± SE. Statistical analysis was performed by using StatView statistical software. For analysis of data, we used a non-parametric Mann–Whitney *U* test for comparison of unpaired groups and the Wilcoxon signed-rank test for comparison of paired data. A confidence level of <0.05 was considered significant.

Results

A total of 34 subjects were first selected. Of the 34 questionnaires mailed, 23 were returned (67.6%). Two questionnaires were not included in the analysis because these applicants were not able to participate or complete the wheelchair race. Ultimately, the study included 21 persons with spinal cord injuries, ranging between 30 and 58 years of age (mean ± SE 42.0 ± 1.74 years), who completed the 18th Oita International Wheelchair Marathon. All the subjects were males. Thirteen non-athletic disabled persons with spinal cord injuries, aged 20–67 years (mean ± SE 39.8 ± 3.72 years), were studied as control subjects. The age, gender and level of spinal cord lesions of the 13 control subjects were matched to those of wheelchair marathon racers. The anthropometric characteristics of subjects are shown in Table 1. The average temperature was 13.8°C and humidity was 67.1% during this period of study.

Figures 1 and 2 show the number of URTI episodes and days with URTI symptoms during the 1-month period before the race and the 2-week post-race period, respectively. The number of URTI episodes in marathoners was 0.086 ± 0.036 per week during the 1-month period before the race and 0.089 ± 0.040 per week during the 2-week post-race period, whereas that of the controls

Table 1 Anthropometric data of the study subjects

	Marathoner (N = *21*)	*Control* (N = *13*)
Age (years)	42.0 ± 1.74	39.8 ± 3.72
Body weight (kg)*	60.7 ± 1.29	67.7 ± 3.52
Height (cm)	171.1 ± 0.76	172.0 ± 1.53
Spinal lesion	T3-L2	T4-L2

Values reported as mean ± SE
*$P<0.05$, significantly different between two groups

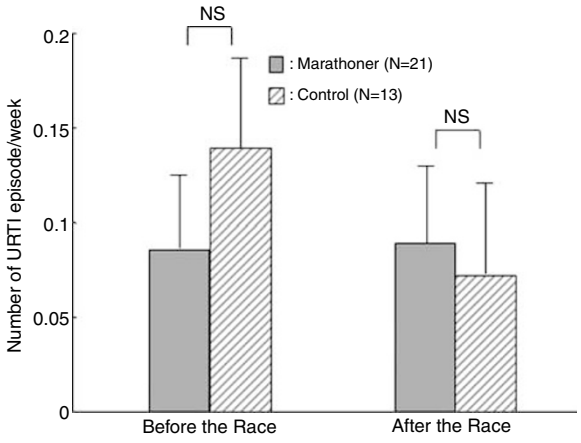

Figure 1 Number of URTI episodes before and after the race. Values reported as mean ± SE. NS, not significant

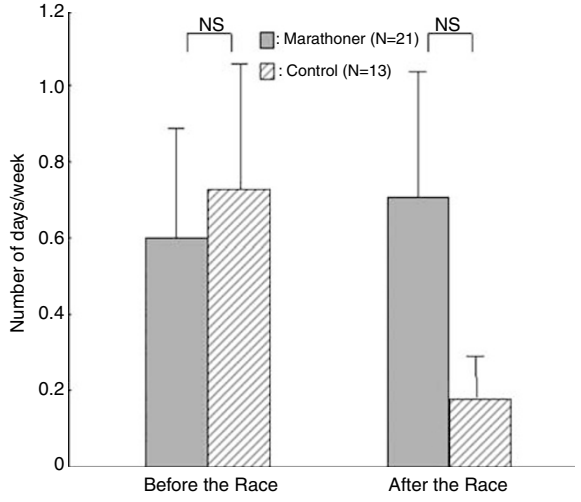

Figure 2 Number of days with URTI before and after the race. Values reported as mean ± SE. NS, not significant

was 0.139 ± 0.046 per week during the 1-month period before the race and 0.072 ± 0.047 per week during the 2-week post-race period. The number of days with URTI symptoms in marathoners was 0.602 ± 0.284 per week during the 1-month period before the race and 0.711 ± 0.366 per week during the 2-week post-race period, whereas that of the controls was 0.730 ± 0.364 per week during the 1-month period before the race and 0.180 ± 0.120 per week during the 2-week post-race period. There were no significant differences between before and after the race in marathoners, or between marathoners and controls during each period.

Of the 21 persons who participated in the wheelchair full marathon race, 8 (38.1%) reported at least one infectious episode throughout the experiment. On the other hand, of the 13 control subjects, 7 (53.8%) reported at least one infectious episode during the time periods indicated. Furthermore, 4 (19.0%) marathoners reported at least one infectious episode during the 2-week post-race period, whereas 2 (15.4%) control subjects reported at least one infectious episode during that time. There was no difference between marathoners who experienced at least one infectious episode throughout the experiment or during the 2-week post-race period and those who reported no infectious episode with respect to age, number of days of training during the experiment, average training distance, total training distance or race time.

Table 2 Results of training and the race

Subjects	*Number of training days during experimental period*	*Running distance in daily training (km)*	*Total training distance (km)*	*Race time (s)*
1	22	14.1	310	8439
2	26	17.5	456	6994
3	28	24.0	673	6467
4	36	18.6	669	6039
5	12	18.3	220	9067
6	12	12.6	151	6995
7	32	16.8	536	6473
8	39	25.6	998	5812
9	27	27.0	728	6046
10	13	18.9	246	6999
11	22	10.9	240	6993
12	34	10.3	351	8419
13	31	15.9	492	6680
14	33	18.3	604	6038
15	22	16.5	363	7327
16	20	24.6	492	7331
17	20	17.4	348	6993
18	26	11.8	306	7188
19	16	25.6	410	7927
20	30	21.6	649	6682
21	25	20.1	502	6986

The number of URTI episodes throughout the experiment, during the 1-month period before the race and the 2-week post-race period, were not related to the time taken to complete the race. In marathoners who completed the race within 2 h ($n = 15$) and those who took more than 2 h to complete the race ($n = 6$), the number of URTI episodes in the 2 weeks after the race was 0.093 ± 0.048 and 0.078 ± 0.071 per week, respectively. No difference was seen between marathoners who completed the race within 2 h and those who completed the race in more than 2 h with respect to age, number of URTI episodes throughout the experiment, before and after the race, number of days with URTI throughout the experiment, before and after the race (Table 2).

Nieman *et al*[11] reported that in able-bodied persons, there was no significant change in reported sickness after the road race despite the high intensity of the race, shown as 'very hard' on perceived exertion during the last 15 min of the race. A score of 17 on Borg's scale indicates that the exercise is very hard.[12] The marathoners who reported 17 or greater as a rating of perceived

exertion (Borg's scale) during the last 15 min of the race ($n=11$) had 0.093 ± 0.059 URTI episode per week during the 2-week post-race period, whereas those who reported the rating of perceived exertion as less than 17 on Borg's scale ($n=10$) had 0.085 ± 0.054 URTI episode per week during the 2-week post-race period. There was no difference between marathoners who reported 17 or greater for a rating of perceived exertion (Borg's scale) during the last 15 min of the race and those who reported a rating of perceived exertion of less than 17 with respect to age, race time or number of URTI throughout the experiment, before and after the race.

Our subjects were divided into two groups according to training distance per week, which is the same division used in the study described by Peters *et al*.[13] The marathoners who trained more than 65 km per week had a 0.170 ± 0.068 URTI episode per week during the 2-week post-race period ($n=11$), whereas those who trained less than 65 km per week had no URTI episode during the same period ($n=10$). We found that the number of URTI episodes in 2 weeks after the race was significantly higher in subjects who trained more than 65 km per week compared to those who trained less than 65 km per week ($P=0.039$).

Discussion

This is the first prospective study evaluating the incidence of symptoms of URTI in disabled athletes before and after a wheelchair competition. The major finding of this study is that in subjects with SCI who completed a wheelchair full marathon race, the incidence of URTI after the race does not increase when compared to that of control subjects or to that of before the race. Peters[6] suggested that the greater incidence of symptoms of infection after the marathon in able-bodied runners was attributed to (a) possible drying of the mucosal surfaces resulting from hyperventilation of cold, dry air, and/or (b) immuno-suppression resulting from elevated serum cortisol levels experienced during the duration of the race

During the wheelchair marathon race, racers have been observed to glide their wheelchairs on descending sections of the race course whereas simultaneously resting their upper limbs.[3] Ogata suggested that a wheelchair marathon differed from a running marathon, as runners never rested their lower extremities. Wheelchair racers used their anaerobic energy system during climbing and could rest their arms during gliding on level or downhill roads.[3] Skillful wheelchair marathon racers will appropriately use aerobic and anaerobic phases and arm resting during the race according to the racer's physical strength, various course grades and individual tactics.[3] These physical, physiological and technical factors in wheelchair marathon races result in short race times (1 h 30 min to 2 h) compared with running marathon races. Also, most of the SCI marathoners in the present study had longer daily training times than their race times. Therefore, drying of the mucosal surfaces resulting from hyperventilation of cold and dry air may, in the case of SCI marathoners, be less during a race than during a daily training day and less in comparison to what is experienced by able-bodied persons when running a marathon.

It has been suggested that saliva immunoglobulin A (sIgA) may decrease over prolonged periods of intensive training in elite able-bodied athletes[14] due to neurohormonal factors related to physical and psychological stress resulting from intensive daily exercise.[15] Of the immune function tests that have shown some change with athletic endeavor, only sIgA has been found to be a potential marker of URTI risk.[14,16] Unfortunately, no study has examined changes of sIgA in disabled persons during intense training and after wheelchair competition. The NK cells are by far the leukocyte subpopulation most responsive to exercise in able-bodied athletes. Previously, we reported that plasma cortisol levels increased immediately after a wheelchair full marathon and the number of peripheral NK cells and NKCA decreased immediately after the race, but they recovered to control levels within 24 h, and we suggested that the immuno-suppression after the wheelchair race was temporal and might not increase the incidence of URTI.[7] The constant URTI episodes in marathoners before racing and post-race supported the previous suggestion.

In this study, 19.0% of SCI marathoners reported at least one infectious episode during the 2-week post-race period, whereas 15.4% of control subjects reported at least one infectious episode during that same period. In able-bodied persons, the rate of URTI episoded in 2311 able-bodied runners who ran in the Los Angeles marathon was 12.9% during a week after the race in comparison with 2.2% of similarly experienced runners who had applied but did not participate.[17] Therefore, the rate of URTI episodes in SCI marathoners might not increase when compared with previous observations in able-bodied persons.[17]

Nieman *et al*[17] reported that athletes who trained for the Los Angeles marathon for more than 96 km per week doubled their odds for infections compared to those who trained less than 32 km per week. Peters *et al*[13] demonstrated that a significant but weaker association was found between the existence of URTI symptoms and high training distance (>65 km) per week in persons who participated in a 56-km ultramarathon race. Our subjects were divided into two groups according to training distance per week in the same way as seen in the study of Peters *et al*, and the number of URTI episodes in the 2 weeks after the race was significantly higher in subjects who trained more than 65 km per week compared to those who trained less than 65 km per week. This result agreed with previous reports.[13,17] The marathon racers who train more than 65 km per week often experience hyperventilation of cold and dry air compared to those who train less than 65 km per week. Therefore, the hypothesis that the greater incidence of symptoms of infection is attributed to possible drying of the mucosal surfaces resulting from hyperventilation of cold, dry air[6] may be applicable to disabled persons during the wheelchair marathon training period.

Conclusion

The results of this study demonstrated that in subjects with SCI who completed a wheelchair full marathon race, the incidence of URTI after the race was not high compared to that of control subjects and that before the race. However, the number of URTI episodes 2 weeks after the race was significantly higher in subjects who trained more than 65 km/week compared to those who trained less than 65 km/week. Therefore, it is recommended that wheelchair marathoners should consider their risk of URTI while doing extraordinarily strenuous or time-consuming practice.

Acknowledgements

We thank Dr Taro Nakamura for his great assistance. We are also grateful to Messrs. Tatsuru Ibusuki, Yukifumi Yamamoto and Hiroshi Takahashi for their help. Finally, we acknowledge the skilful assistance of Ms Satoko Aoki and Ms Aya Katayama.

References

1 Toyonaga T. Etiology of spinal cord injury. In: Sumida M, Tokuhiro A, Magara A, Toyonaga T, Uchida R (eds). *Rehabilitation Outcome of Persons with Spinal Cord Injury in Japan*. Ishiyaku Publishers: Tokyo 2001, pp 28–42.
2 Tajima F *et al*. Circulating muscle enzymes and natural killer cell activities during and after wheelchair full marathon race in individuals with spinal cord injuries. In: Nose H, Gisolfi CV, Imaizumi K, Cooper IL (eds). *Exercise, Nutrition, and Environmental Stress*. Vol 1. Traverse City, MI 1999, pp 259–274.
3 Ogata H. A review of wheelchair marathon and tennis. *J UOEH* 1994; **16:** 201–217.
4 Mackinnon LT. Immunity in athletes. *Int J Sports Med* 1997; **18**(Suppl 1)**:** S62–S68.
5 Nieman DC. Exercise immunology: practical applications. *Int J Sports Med* 1997; **18**(Suppl 1)**:** S91–S100.
6 Peters EM. Exercise, immunology and upper respiratory infection. *Int J Sports Med* 1997; **18**(Suppl 1)**:** S69–S77.
7 Furusawa K, Tajima F, Tanaka Y, Ide M, Ogata H. Short-term attenuation of natural killer cell cytotoxic activity in paraplegic athletes during wheelchair marathon. *Arch Phys Med Rehabil* 1998; **79:** 1116–1121.
8 Furusawa K, Tajima F, Ueta M, Ogata H. Activation of natural killer cell function in recreational athletes with paraplegia during wheelchair half marathon race. *Arch Phys Med Rehabil* 2003; **84:** 706–711.
9 Bhatt K, Cid E, Maiman D. Bacteremia in the spinal cord injury population. *J Am Paraplegia Soc* 1987; **10:** 11–14.
10 Kostka T, Berthouze SE, Lacour J-R, Bonnefoy M. The symptomatology of upper respiratory tract infections and exercise in elderly people. *Med Sci Sports Exerc* 2000; **32:** 46–51.
11 Nieman DC, Johanssen LM, Lee JW. Infectious episodes in runners before and after a roadrace. *J Sports Med* 1989; **29:** 289–296.
12 Borg G. Perceived exertion as an indicator of somatic stress. *Scand J Rehabil Med* 1970; **2:** 92–98.
13 Peters EM, Bateman ED. Ultramarathon running and upper respiratory tract infections. *S Afr Med J* 1983; **64:** 582–584.
14 Pyne DB, Gleeson M. Effect of intensive exercise training on immunity in athletes. *Int J Sports Med* 1998; **19**(Suppl 3)**:** S183–S194.
15 Mackinnon LT. Immunoglobulin, antibody, and exercise. *Exerc Immunol Rev* 1996; **2:** 1–35.
16 Gleeson M *et al*. Salivary IgA levels and infection risk in elite swimmers. *Med Sci Sports Exerc* 1999; **31:** 67–73.
17 Nieman DC, Johanssen LM, Lee JW, Arabatzis K. Infectious episodes in runners before and after the Los Angeles Marathon. *J Sports Med Phys Fitness* 1990; **30:** 316–328.