Regular Article

Title: Marathon time and running distance before marathon race on runners who live in cold, snowy regions

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Abstracts

We aimed to examine the relationship between marathon time and running distance in the 8 months before the race for runners who live in cold, snowy regions and those who do not. A questionnaire was conducted for male runners who participated in the 2018 Hokkaido Marathon held at the end of August. The subjects were divided into runners from Hokkaido (Hokkaido runners), which is a cold and snowy region, and runners from other regions (non-Hokkaido runners). In addition, Hokkaido and non-Hokkaido runners were divided into two groups, high-volume and low-volume runners, based on their average running distance over an 8-month period. Regardless of high-volume or low-volume, Hokkaido runners' monthly running distances significantly increased from March compared to January, but non-Hokkaido runners showed no change in their monthly running distances. For non-Hokkaido runners, a significant correlation was found between cumulative monthly running distance and marathon time starting from 8 months prior to the marathon. On the other hand, among Hokkaido runners, no correlation was found between accumulative monthly running distance and marathon time for low-volume runners from January to April, or for high-volume runners from January to February or January to March. These results suggest that marathon times for runners in cold, snowy regions are more closely linked to seasonal changes in running distance than for other runners.

Keywords: distance running, marathon performance, runner, training period, training volume

タイトル: 寒冷積雪地のランナーの月間走行距離とマラソンタイム

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要旨

本研究の目的は積雪寒冷地に住んでいるランナーとそうでないランナーを対象に、レース前 8 ヶ月間の走行距離とマラソンタイムとの関係を調べることである。 研究は 8 月末に開催され 2018 北海道マラソンに参加した男性ランナーを対象として、アンケート調査を行った。対象者は、積雪寒冷地である北海道のランナー（北海道ランナー）と、その他の地域のランナー（道外ランナー）に分け、さらに北海道と北海道以外のランナーを、8 ヶ月間の平均走行距離に基づいて、走行距離の長いランナーと少ないランナーの 2 つのグループに分類した。走行距離の長い、少ないに関わらず北海道のランナーでは、3 月以降に月間走行距離が 1 月よりも有意に増加したが、北海道以外のランナーでは月間走行距離に変化がみられなかった。北海道以外のランナーでは、大会前 8 か月前から月間走行距離とマラソンのタイムの間には有意な相関関係がみられた。一方、北海道のランナーにおいて、走行距離の少ないランナーでは 1 月から 4 月の期間に、また走行距離の長いランナーでは 1 月から 3 月、1 月から 4 月の蓄積月間走行距離とマラソンのタイムの間に相関は認められなかった。この結果は、寒冷積雪地のランナーでは、マラソンタイムが季節による走行距離の変化に連動していることを示唆する。

Introduction

Today, many marathon races are held worldwide. (*1*). Many elite and recreational runners train daily to perform well in marathon races (*2,3,4*). Several studies have reported that marathon time is influenced by training indices (*5,6,7,8,9,10*) as well as by anthropometric (*6,11*) and physiological (*5,6,8,11*) variables. Previous studies have suggested that training indices such as training frequency (*9,10*) training volume (*9,10,12,13*) and running pace (*9,10*) are important predictors of marathon time. Tanda (*9*) reported a significant relationship between average running distance per week and marathon time, with correlation coefficient of 0.81. Yamaguchi et al. (*14*) reported that monthly training volume for recreational runners was the most important factor in predicting marathon time. Thus, training volume is considered one of the most important training indices for marathon time.

Hokkaido, Japan, is located in a cold and snowy region during the winter. The Hokkaido Marathon, held at the end of August, is the largest marathon event in the region. Runners in Hokkaido tend to run less distance due to the harsh running environment during the winter, and it is known that they increase their running distance during the summer in preparation for the Hokkaido Marathon (*15*). On the other hand, all regions of Japan other than Hokkaido have marathon races even during the winter, and runners who do not live in Hokkaido run throughout the year. These runners from outside Hokkaido account for approximately half of the participants in the Hokkaido Marathon. The Hokkaido Marathon can be considered an event in which runners who train under various training conditions participate together.

One of the important issues in marathon performance is how long the pre-competition training phase should be for a marathon race. Some web pages state that most typical marathon training plans are 16 to 20 weeks long (*16,17*), but no supporting evidence or research papers are available. It has been shown that 4 to 12 weeks of training can improve VO2max, running velocity at lactate threshold, and running efficiency in marathon runners (*18,19*). However, there is limited information on how long before a marathon race runners should start training before a race, and it is not clear when the relationship between marathon time and training volume will be established.

Runners living in Hokkaido increase their running distance after April when the snow melts (*15*). In a sense, this means that runners living in Hokkaido approach the Hokkaido Marathon after a break from training every year. On the other hand, runners outside Hokkaido participate in marathon races with continuous training. Training before a marathon race may have a greater impact on marathon times for runners who run seasonally or who train infrequently than for runners who train year-round. Examining the relationship between training volume and marathon time for runners with different training environments may provide important information for estimating the period required for marathon training. It is unclear how these differences in training conditions affect marathon times.

To clarify the differences in training effectiveness before a marathon depending on the region of residence, we investigated the relationship between marathon time and running distance in the 8 months before the race for runners living in Hokkaido and runners living elsewhere. In addition, considering the difference in the influence of training volume, we investigated the relationships between marathon time and monthly running distances by dividing runners into those who trained less and those who trained more.

Methods

Subjects

Male recreational runners who participated in the Hokkaido Marathon 2018 (n=597) completed a questionnaire before the race. The subjects were informed of the aims and possible risks associated with the survey and provided written informed consent to participate in this study. A total of 487 runners completed the race and were included in this study. The Hokkaido Marathon was held on August 26, 2018, and the duration was restricted to 5 hours. At the start of the race, the weather conditions included 22.0 °C and 75% humidity. The marathon completion rate of the subjects in this study was 81.6%, which is similar to that of all male runners, according to the official announcement (82.0%). This study was conducted as a part of the Hokkaido Marathon 2018 Research Project and

approved by the Ethics Committee of Health Sciences University of Hokkaido (approval number 17R060056).

Procedures

The survey was conducted at the reception area on one and two days before the race, with the consent of the Hokkaido Marathon Organizing Committee. The questionnaire items included entry number, age, body height, body weight, place of residence and monthly running distance. Entry number, body height and weight, place of residence, and runners' monthly running distances during the last eight months, were obtained through free descriptive answers. The runners indicated their age according to the following categories: 20s or below, 30s, 40s, 50s, and 60s or above. When calculating the average age, values for age groups such as 20s and 30s were used as 25 and 35 years old. Body mass index (BMI) was calculated from the height and weight provided in the free descriptive answers. The marathon time of each runner was obtained by referring to the official website with the entry number. Although a survey was also conducted on female runners, due to the relatively small number of participants in the Hokkaido Marathon and the small number of people who responded to the survey, this study only included men. The participants' physical characteristics, monthly running distance and marathon time are shown in Table 1.

Hokkaido is a cold and snowy region in the winter, and the monthly running distance of Hokkaido runners varies greatly depending on the season; therefore, the subjects were divided into runners from Hokkaido (Hokkaido runners) and runners from other regions (non-Hokkaido runners). In addition, considering the difference in the influence of running volume on marathon performance, Hokkaido and non-Hokkaido runners were divided into two groups, high-volume and low-volume runners, based on their average running distance over an 8-month period: 137.7 km (Table 1). Hokkaido runners tend to run less during the winter. We hypothesized that runners with low training volumes in particular hardly train at all during the winter, which resets the cumulative training effect. We thought that by examining the correlation between running distance and marathon time several months before the race in low-volume runners, for whom the effects of training are reset, we might

79 be able to clarify the characteristics of the training effects on marathon performance for runners in
80 snowy, cold regions. We conducted this study with the hope that dividing the participants into two
81 groups based on the average running distance would provide some information about differences in
82 the effects based on training volume.
83 Statistics
84 The data are expressed as the means and standard errors. Analysis of the data was performed using
85 IBM SPSS Statistics version 26 (IBM, Chicago, IL). The monthly running distances of all runners
86 were compared using one-way repeated measures analysis of variance (time), followed by multiple
87 comparisons with Bonferroni correction. Age, body height and weight, BMI, average running
88 distance and marathon time were compared between Hokkaido and non-Hokkaido runners using the
89 Mann-Whitney U test. Monthly running distances in Hokkaido and Non-Hokkaido runners classified
90 as high-volume or low-volume runners were compared using two-way repeated measures analysis of
91 variance (group x time), followed by post-hoc testing using Bonferroni correction. Taking into
92 account the age difference between Hokkaido and non-Hokkaido runners and the influence of
93 anthropometric data on marathon time, the relationship between cumulative monthly running
94 distance and performance was analyzed using partial correlation by multiple regression analysis with
95 age and BMI as adjustment factors. The significance level was set at $p<0.05$.
96
97 Results
98 Average monthly running distance and marathon time for all runners were 137.7±3.92 km and
99 4:11:43±1:35, respectively (Table 1). Changes in the monthly running distance of all runners for 8 Table 1
100 months before the marathon race are shown in Fig. 1. The monthly distances in April, May, June,
101 July and August increased significantly compared with those in January. The partial correlations Fig. 1
102 between accumulative monthly running distances and the marathon times, controlling for age and
103 BMI, for all runners are shown in Table 2. For all runners, there were significant correlations Table 2
104 between all accumulative monthly running distances and marathon time.

Table 3 shows the physical characteristics, monthly running distances and marathon time of Hokkaido and non-Hokkaido high-volume and low-volume runners. The high-volume and low-volume runners were classified based on their average running distance over an 8-month period: 137.7 km. As a result, the numbers of high-volume runners within Hokkaido and outside Hokkaido were 96 and 113, respectively, and the numbers of low-volume runners were 146 and 132, respectively. The ages of high-volume Hokkaido and non-Hokkaido runners were significantly greater than those of low-volume Hokkaido and non-Hokkaido runners, respectively. On the other hand, body height and weight, BMI, monthly running distance and marathon time did not differ between Hokkaido runners and non-Hokkaido runners, regardless of whether they were high-volume or low-volume runners.

Table 3

Changes in the monthly running distances of Hokkaido and non-Hokkaido runners classified as high-volume runners are shown in Fig. 2. The monthly distances reported for April, May, June, July and August were significantly greater than those in January for high-volume Hokkaido runners. On the other hand, there were no significant differences in the monthly running distances between high-volume non-Hokkaido runners. The monthly distances in January and February for high-volume Hokkaido runners were significantly lower than those for non-Hokkaido runners. There were no differences in monthly running distances after April between Hokkaido and non-Hokkaido high-volume runners.

Fig. 2

Changes in the monthly running distances of Hokkaido and non-Hokkaido runners classified as low-volume runners are shown in Fig. 3. The monthly distances in March, April, May, June, July and August for low-volume Hokkaido runners were significantly greater than those in January. On the other hand, there were no significant differences in monthly running distances of low-volume non-Hokkaido runners of Low-volume. The monthly distances in January, February and March for low-volume Hokkaido runners were significantly lower than those for non-Hokkaido runners. The monthly distances in May, June, July and August for low-volume Hokkaido runners were significantly greater than those for non-Hokkaido runners.

Fig. 3

The partial correlations between accumulative monthly running distances and the marathon times, controlling for age and BMI, in Hokkaido and non-Hokkaido runners classified as high-volume and low-volume. are shown in Table 4. For non-Hokkaido runners, regardless of whether they were low-volume or high-volume, a significant correlation was found between cumulative monthly running distance and marathon time starting from 8 months prior to the marathon. On the other hand, among Hokkaido runners, no correlation was found between accumulative monthly running distance and marathon time for low-volume runners from January to April, or for high-volume runners from January to February or January to March.

Table 4

Discussion

There were no differences in monthly running distances between winter and summer for high-volume and low-volume non-Hokkaido runners, indicating that runners who do not live in cold, snowy regions have similar training volumes throughout the year. On the other hand, runners from Hokkaido, who live in cold, snowy regions, tend to run less in the winter and increase their running volume in the summer. Despite these differences in training conditions, there was no difference in marathon performance between Hokkaido runners and non-Hokkaido runners. It is known that training volume has a strong relationship with marathon time (*9,14*). The reason why the marathon times of Hokkaido runners and non-Hokkaido runners were the same despite their different training conditions, which suggests that the Hokkaido runners may have compensated for the decrease in training volume in winter by increasing training volume before the marathon race. This means that if runners train well in the months leading up to a marathon, they can perform as well as runners who train year-round. It has been shown that 4 to 12 weeks of training can improve VO2max, running velocity at lactate threshold, and running efficiency in marathon runners (18,19). Some web pages state that most common marathon training plans are 16 to 20 weeks long (*16,17*). While this study cannot provide any indication of how long training sessions might be needed to compensate for

reduced winter training volume, it would provide evidence supporting the importance of training in the months leading up to a marathon.

For non-Hokkaido runners, significant partial correlations were found between accumulative monthly running distances and marathon times during the 8 months before the marathon. On the other hand, no partial correlation was found between monthly cumulative running distance from January to April and marathon performance in low-volume Hokkaido runners, or between monthly cumulative running distance from January to March and marathon performance in high-volume Hokkaido runners. This may be evidence that in Hokkaido runners, the effects of previous training are reset during the winter due to a decrease in running volume. Comparing the monthly running distances in January and February with those in June and July, the difference was over 70km for both low-volume and high-volume Hokkaido runners. Numerous studies have shown that long-term detraining reduces aerobic capacity and endurance performance (*20,21,22*). Feely et al. (*20*) reported that taking a break from training for more than seven days reduces marathon performance by 5-8%. Pedlar et al. (*21*) showed that marathon runners who limited low-intensity exercise to less than 2 hours per week experienced a continuous decline in endurance performance over an 8-week period. Even for high-volume runners, a large reduction in training volume over a certain period of time may have a detraining-like effect. Therefore, the long-term reduction in training volume over the 2-month period of this study may have led to a loss of association with marathon performance.

In Hokkaido runners, significant partial correlations between marathon time and accumulative monthly running distances appeared several months before the marathon race as their running distances increased. This result shows that the relationship between training and marathon time is modified with a several months of training. Akizuki et al. (*15*) reported that Hokkaido runners tend to run less distance due to the harsh running environment during the winter, and they increase their running distance during the summer in preparation for the Hokkaido Marathon. However, they did not investigate the relationship between training volume and marathon time. This study is the first to

show that changes in training volume during the months before a marathon in a cold, snowy region affect marathon times.

Many athletes prepare for competitions by varying their training intensity and volume (*23*). This study focuses on training volume and therefore cannot provide insight into training intensity. It is known that 75% to 80% of endurance athletes, including runners, undergo low-intensity training with an emphasis on training volume (*24,25*). Additionally, training volume is known to be closely related to marathon times (*9,14*). When considering how training contributes to marathon times, information about training intensity must be considered in addition to training volume, but we believe that this study, which shows the relationship between training volume before a marathon race and marathon time, will provide important information for marathon training plans.

This study has several potential limitations. In order to generalize the results of this study, future surveys of a variety of runners, such as elite runners and female runners, will be necessary. This study used self-reported data and did not determine running distance using objective data such as GPS records. Therefore, there is a possibility that the actual running distance may differ to some extent. However, many runners keep track of their running distance by wearing a GPS-enabled watch or by running a set course. We decided to conduct this study based on self-reported data because we felt that the approximate running distance could be determined from the distance and frequency of each training session, and that even though it was self-reported data, reliability could be ensured by collecting data from a large number of runners. In areas with heavy snowfall such as Sapporo and Asahikawa, which account for roughly half of Hokkaido's population, sidewalks are buried in snow during the winter, making it difficult to run outdoors. For this reason, runners in Hokkaido tend to run on treadmills at training gyms during the winter. Although this study counted indoor treadmill running as part of the running distance, it did not investigate what kind of cross-training the Hokkaido runners were doing, and the impact of exercise other than running is unknown. This study showed the effect that changes in training volume from winter to the summer marathon for runners in cold, snowy regions have on marathon times. but it does not go so far as to provide

training information to improve performance. The question of optimal training intensity and duration to improve performance are topics for future study.

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Authors' contribution

All authors contributed to the study conception and design. AY contributed to the interpretation of the results and the manuscript drafting. AA and KI significantly contributed to data aggregation and analysis. TF developed the statistical analysis plan and interpretation. KS substantially contributed to the manuscript drafting. All authors read and approved the final version of the manuscript.

Conflict of interest

The author(s) declare that there are no conflicts of interest.

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293
294

Table 1 Physical characteristics, average running distance and marathon time for all runners.

	Age (n=487) (yrs)	Body height (n=487) (cm)	Body weight (n=487) (kg)	BMI (n=487) (kg/m^2)	Average running distance (n=487) (km)	Marathon time (n=487) (hr:min:sec)
Mean	48.1	170.9	63.3	21.6	137.7	4:11:43
±SEM	±0.55	±0.26	±0.32	±0.09	±3.92	±1:35

Table 2 The partial correlations between accumulative monthly running distances and the marathon times, controlling for age and BMI, for all runners.

	Jan (km)	Jan-Feb (km)	Jan-Mar (km)	Jan-Apr (km)	Jan-May (km)	Jan-Jun (km)	Jan-Jul (km)	Jan-Aug (km)
Marathon time	-0.524**	-0.520**	-0.525**	-0.542**	-0.556**	-0.568**	-0.583**	-0.592**

Mean ±SEM. ** $p<0.01$.

Table 3 Physical characteristics, monthly running distance and marathon time of Hokkaido and non-Hokkaido high-volume and low-volume runners.

	number	Age	Body height	Body weight	BMI	Monthly running distance	Marathon time
		(yrs)	(cm)	(kg)	(kg/m^2)	(km)	(hr:min:sec)
high-volume							
Hokkaido	96	52.7	169.7	62.1	21.6	212.7	4:00:05
		±1.02	±0.56	±0.61	±0.18	±6.72	±3:35
non-Hokkaido	113	49.1*	171.1	62.3	21.3	221.4	3:51:06
		±1.09	±0.57	±0.61	±0.18	±6.50	±3:28
low-volume							
Hokkaido	146	47.9	171.0	63.7	21.8	80.0	4:26:35
		±0.99	±0.47	±0.56	±0.14	±2.91	±2:13
non-Hokkaido	132	44.2*	171.5	64.5	21.9	75.1	4:21:20
		±1.11	±0.49	±0.71	±0.19	±3.21	±2:36

*$p<0.05$ show significant differences between Hokkaido and non-Hokkaido.

Table 4 The partial correlations between accumulative monthly running distances and the marathon times, controlling for age and BMI, in Hokkaido and non-Hokkaido runners classified as high-volume and low-volume.

	Jan (km)	Jan-Feb (km)	Jan-Mar (km)	Jan-Apr (km)	Jan-May (km)	Jan-Jun (km)	Jan-Jul (km)	Jan-Aug (km)
high-volume								
Hokkaido	-0.230*	-0.191	-0.197	-0.241*	-0.248*	-0.262*	-0.286**	-0.313**
non-Hokkaido	-0.460**	-0.452**	-0.452**	-0.449**	-0.453**	-0.461**	-0.484**	-0.501**
low-volume								
Hokkaido	-0.071	-0.076	-0.085	-0.130	-0.229**	-0.303**	-0.376**	-0.396**
non-Hokkaido	-0.209*	0.219*	-0.227**	-0.224*	-0.217*	0.219*	-0.226*	-0.234**

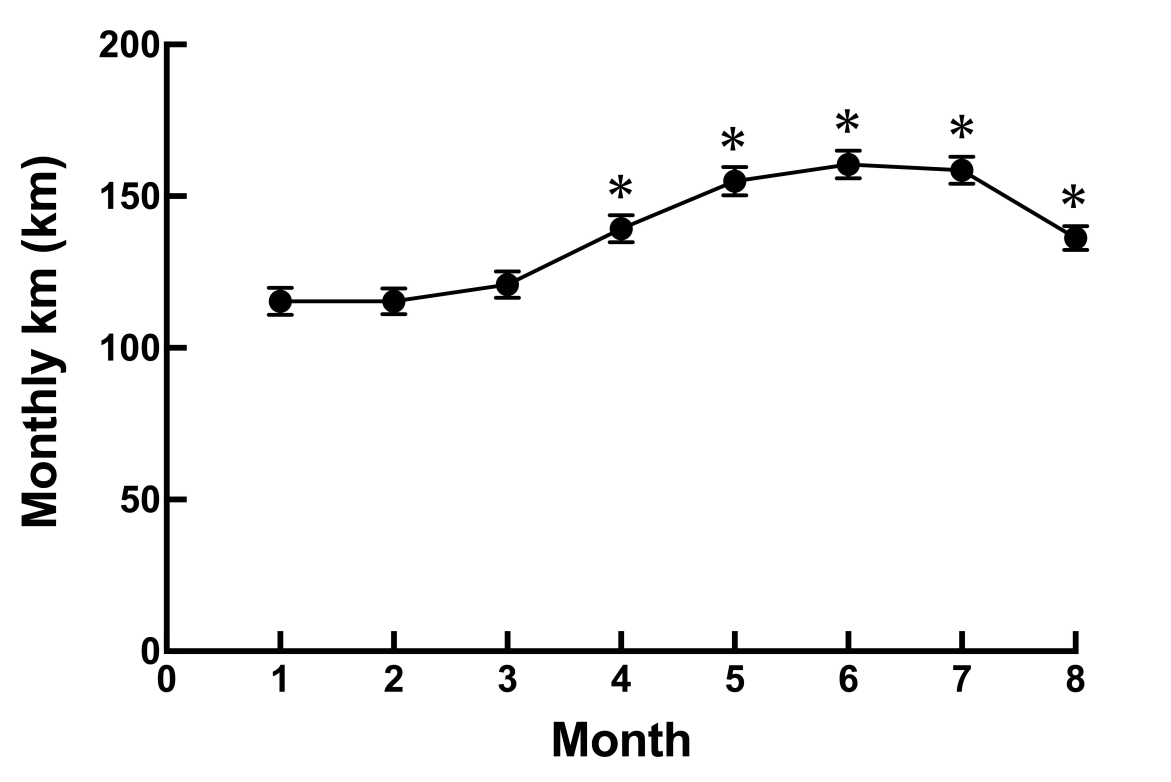
*p<0.05, **p<0.01.

Figure legends

Fig. 1 Changes in the monthly running distance of all runners for 8 months before marathon race.
*p<0.05 show significant differences from monthly running distance in January.

Fig. 2 Changes in the monthly running distances of Hokkaido and non-Hokkaido runners classified as high-volume runners.
*p<0.05 show significant differences from monthly running distance in January of non-Hokkaido runners. †p<0.05 show significant differences between Hokkaido and non-Hokkaido runners.

Fig. 3 Changes in the monthly running distances of Hokkaido and non-Hokkaido runners classified as low-volume runners.
*p<0.05 show significant differences from monthly running distance in January of non-Hokkaido runners. †p<0.05 show significant differences between Hokkaido and non-Hokkaido runners.


200
150
100
50
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Monthly km (km)
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1
2
3
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Month
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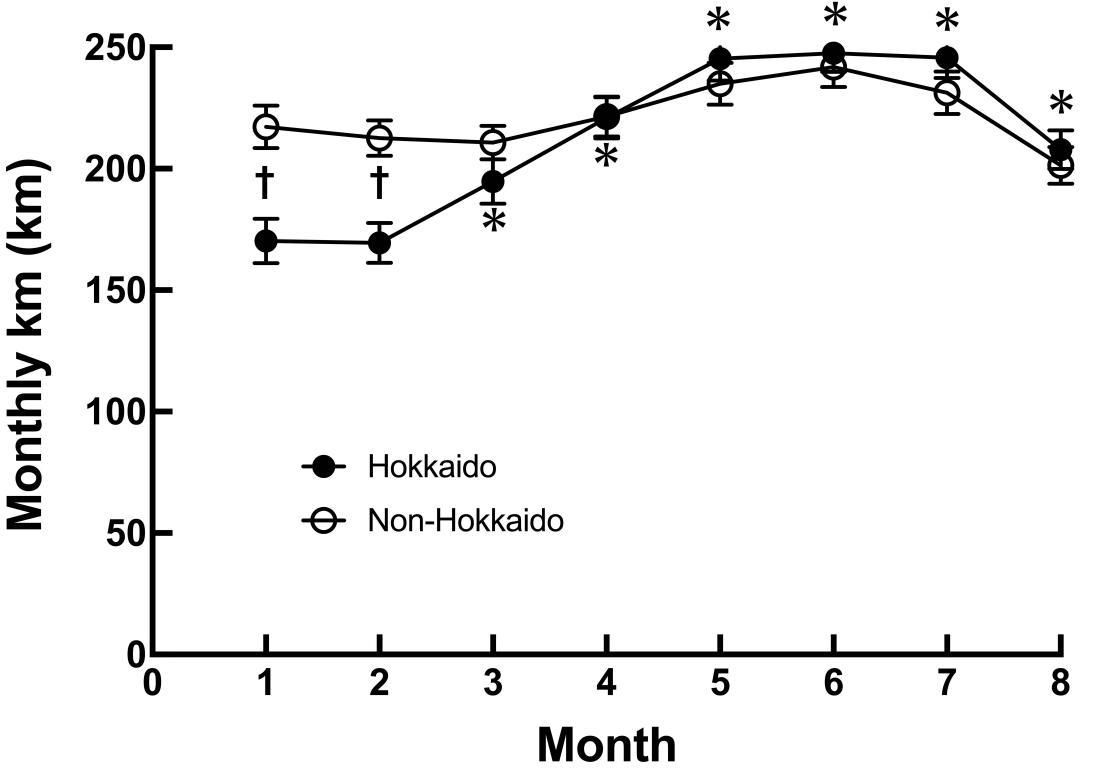
250
200
150
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Monthly km (km)
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Month
Hokkaido
Non-Hokkaido
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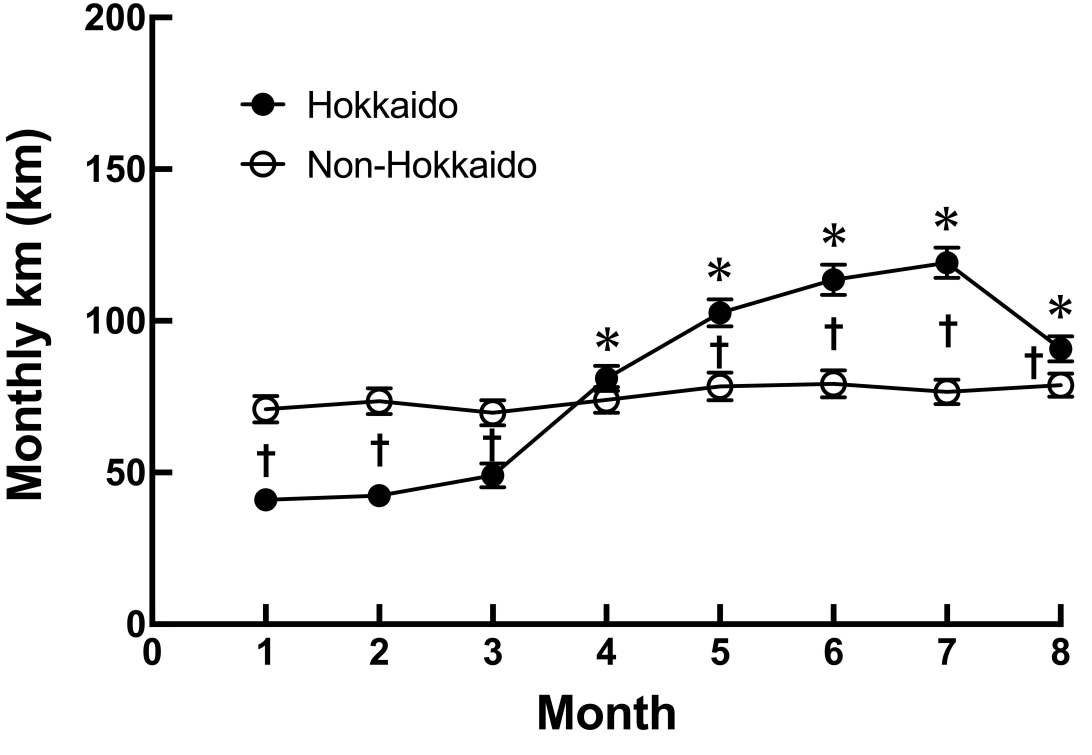
200
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Monthly km (km)
Hokkaido
Non-Hokkaido
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