

# Alterations in Urine Specific Gravity during Three Consecutive Days of Kendo Practices

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**Abstract :** There is limited comprehensive research into hydration status during regular practices of collegiate kendo players. The purpose of this study was to determine variations of urine specific gravity during three consecutive days of kendo practices. Twenty one male collegiate kendo players served as the subjects [age :  $19.7 \pm 1.1$  year, height :  $170.2 \pm 6.1$  cm, body weight :  $68.8 \pm 10.4$  kg, BMI :  $23.8 \pm 3.4$  kg/m<sup>2</sup>, Body fat :  $16.7 \pm 11.8$  % (mean  $\pm$  SD)]. During three consecutive days (Day 1 : Wednesday ; Day 2 : Thursday ; Day 3 : Friday), the urine specific gravity (USG) was assessed using a handheld refractometer before (Pre) and after (Post) kendo practices. Daily practices consisted of 5 min warm-up, 10 min *suburi*, 15 min *kiri-kaeshi*, 40 min *kihon-geiko*, 25 min *ji-geiko*, 20 min *kakari-geiko* and 5 min *kiri-kaeshi*. A total of daily practices lasted 2 hours. A two-way analysis of variance (ANOVA) with repeated measures revealed no significant main effects for phase in USG, whereas there were significant main effects for time (Pre= $1.022 \pm 0.009$ , Post= $1.029 \pm 0.006$  for Day 1 ; Pre= $1.020 \pm 0.006$ , Post= $1.027 \pm 0.007$  for Day 2 ; Pre= $1.023 \pm 0.007$ , Post= $1.028 \pm 0.006$  for Day 3,  $p < 0.05$ ). These findings suggest that most collegiate kendo players appear to be moderately dehydrated during daily practices, which could offer coaches, medical staff, and athletes insights into their hydration status for developing procedures to maintain adequate hydration.

大学剣道選手の日常稽古における脱水症状の検討に関する研究は限られている。本研究の目的は、大学剣道選手の日常稽古中の脱水症状を検討することであった。被検者は、環太平洋大学体育会剣道部に所属する男子剣道部員21名であった [age :  $19.7 \pm 1.1$  year, height :  $170.2 \pm 6.1$  cm, body weight :  $68.8 \pm 10.4$  kg, BMI :  $23.8 \pm 3.4$  kg/m<sup>2</sup>, Body fat :  $16.7 \pm 11.8$  % (mean  $\pm$  SD)]。連続する3日間（水曜日、木曜日、金曜日）で、剣道の稽古は、5分のウォームアップ、10分の素振り、15分の繰り返し、40分の基本稽古、25分の地稽古、20分の掛かり稽古、及び5分の繰り返しから構成された。それらの練習は、一日当たり約2時間に及んだ。剣道の稽古前後で、脱水症状の指標となる尿比重値を測定した。二元配置分散分析により、剣道の稽古前後で有意な差がみられた (Pre= $1.022 \pm 0.009$ , Post= $1.029 \pm 0.006$  for Day 1 ; Pre= $1.020 \pm 0.006$ , Post= $1.027 \pm 0.007$  for Day 2 ; Pre= $1.023 \pm 0.007$ , Post= $1.028 \pm 0.006$  for Day 3,  $p < 0.05$ )。これらの結果から、大部分の大学男子剣道選手は稽古中に脱水症状の傾向にあることが示唆された。このことは、選手・コーチ・医療サポートスタッフに対して、十分な水分補給に関する至適手段を考察する際に、重要な手がかりを提供する。

## INTRODUCTION

Several methods have been introduced to assess hydration status regarding acute fluid loss (Silva et al., 2010). Although determination of plasma osmolality is regarded as the gold standard to measure hydration status (Casa et al., 2005), it requires invasive procedures which are not practical in field settings. In this respect, simple biomarkers such as urine osmolality as well as urine specific gravity are practical measurements with reasonable accuracy and reliability to predict hydration status with athletes (Sawka et al., 2007). Outcomes from those investigations could offer athletes insights into their hydration status and could be beneficial to coaches, medical staff, and athletes in developing procedures to maintain adequate hydration (Oppliger et al., 2005).

While dehydration is referred to as a dynamic loss of body water or the transition from euhydration to hypohydration, euhydration is regarded as normal body-water content (Sawka, 1992). In addition, hypohydration is defined as a body-water deficit (Sawka, 1992). Sufficient hydration and fluid replacement are essential for enabling competitive athletes to optimally perform and maintain overall health (Volpe et al., 2009).

Before athletes are acclimatized to heat, the effects of clothing or uniforms on body heat storage are significant, especially in some sports such as American Football (Godek et al., 2006). Similar to this, kendo (one of the Japanese martial arts similar to fencing) players wearing a traditional Japanese style of clothing, protective armors and *shinai* (a traditional Japanese sword made of bamboo) appear to trap heat and reduce dissipation. In this regard, according to Armstrong et al. (2007), athletes should remove as much protective equipment as possible to permit heat loss and to reduce the risks of hyperthermia, especially during acclimatization.

Although previous research has demonstrated hydration status in many sports, there was still the limitation of the research in collegiate kendo players concerning hydration status during daily practices. Furthermore, research related to hydration status

of kendo players will shed light on several issues in order to maintain optimal euhydration. Therefore, the purpose of this study was to determine variations of urine specific gravity during three consecutive days of kendo practices.

## METHODS

### *Subjects*

Twenty one male collegiate kendo players served as the subjects. Physical characteristics of the subjects are shown in Table 1. All subjects had no significant systemic disease and were not taking any medication at the time of the study. This study was performed according to the Declaration of Helsinki and approved by the Ethics Committee of the International Pacific University.

Table 1. Physical characteristics of the subjects (N=21)

Variable	Mean±SD
Age (years)	19.7±1.1
Height (cm)	170.2±6.1
Body mass (kg)	68.8±10.4
BMI (kg/ m <sup>2</sup> )	23.8±3.4
Body fat (%)	16.7±11.8
Body surface area (m <sup>2</sup> )	1.748±0.137

All data are mean±SD.

### *Overall protocol*

Daily practices consisted of 5 min warm-up, 10 min *suburi* (unadorned swing with *shinai* which is a traditional Japanese sword made of bamboo), 15 min *kiri-kaeshi* (practice of attacking and receiving strikes with a *shinai*), 40 min *kihon-geiko* (variety kinds of fundamental practice with *shinai*), 25 min *ji-geiko* (undirected practice with *shinai*), 20 min *kakari-geiko* (short, intense and attack practice with *shinai*) and 5 min *kiri-kaeshi* (Figure 1).

During all practice sessions, the wet-bulb globe temperature (WBGT) was measured with a WBGT-203A system (Kyoto Electronics Manufacturing Co., LTD.) as the WBGT provides an index for comparing

environmental heat stress across practice sessions (Daanen et al., 2011). All subjects were allowed to drink water *ad libitum* during each training session over three consecutive days.

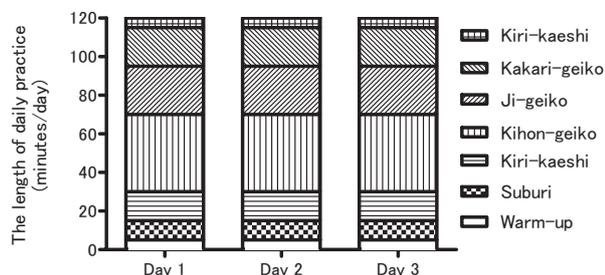


Figure 1. Composition of daily kendo practices which mainly consisted of seven parts.

### Urine Specific Gravity

As shown by Gaines et al. (2010), the urine specific gravity was measured using a handheld refractometer (MASTER-URC/Ja, ATAGO Japan, Inc.). Distilled water was used to calibrate the refractometer before each use (Sherwood, 1999). While the instrument was in a horizontal position, a small drop of urine was placed on the prism, and the cover plate was placed over it. The scale seen in the eyepiece was focused, and the specific gravity was determined.

### Thermal Sensation and Ratings of Perceived Exertion

During three consecutive days, thermal sensation was recorded with a modified scale (-3 : cold, -2 :

cool, -1 : slightly cool, 0 : neutral, +1 : slightly warm, +2 : warm, +3 : hot, +4 : very hot, and +5 : very very hot) before and after kendo practices based on an original scale shown by Gagge et al. (1969). At the same time, ratings of perceived exertion were also measured before and after kendo practices over three consecutive days.

### Statistical Analysis

A two-way analysis of variance (ANOVA) with repeated-measures was performed for each dependent variable. A Tukey's Post Hoc test was used to identify the specific difference when an overall difference was identified. Statistical analysis was performed using STATISTICA version 5.0 for Windows.

## RESULTS

During three consecutive days of kendo practices, the WBGT ranged from 19.4°C to 21.9°C over three days of kendo practices, and the thermal stress was classified as “moderate risk” represented by a WBGT of 18°C ~23°C (Daanen et al., 2011).

With regard to USG, there were significant main effects for time ( $p < 0.05$ ), whereas no significant main effects for phase or interactions were observed over three consecutive days (Figure 2). In terms of both TS and RPE, significant main effects for time were found ( $p < 0.05$ ), but there were no significant main effects for phase or interactions (Figure 3-A and 3-B). Furthermore, linear regression analysis of the

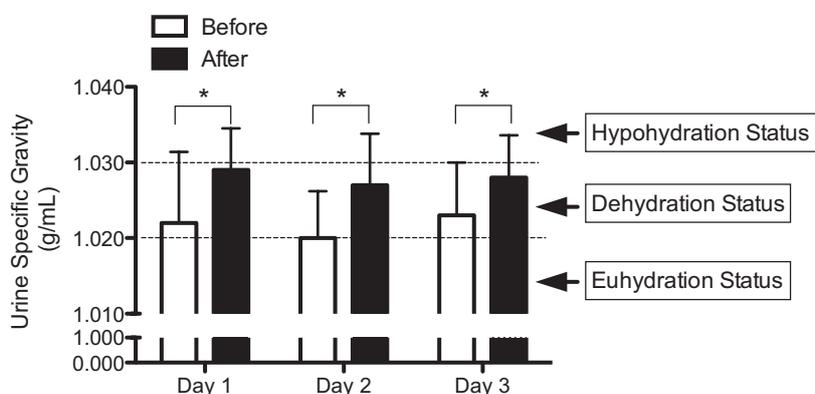


Figure 2. Urine specific gravity before and after kendo practices over three consecutive days (\*main effect for time,  $p < 0.05$ ).

present data demonstrated significant correlations between USG and RPE ( $p < 0.05$ , Figure 4).

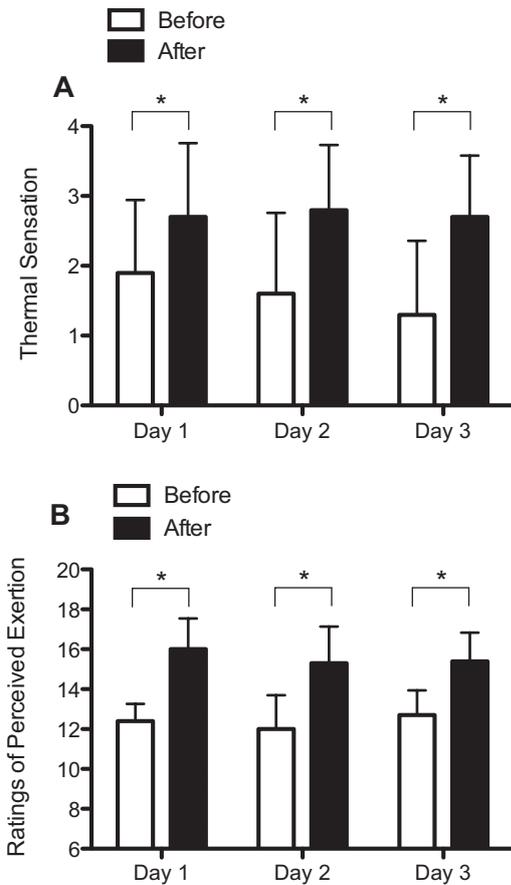


Figure 3. Thermal sensation and ratings of perceived exertion before and after kendo exercise during three consecutive days (\*main effect for time,  $p < 0.05$ ).

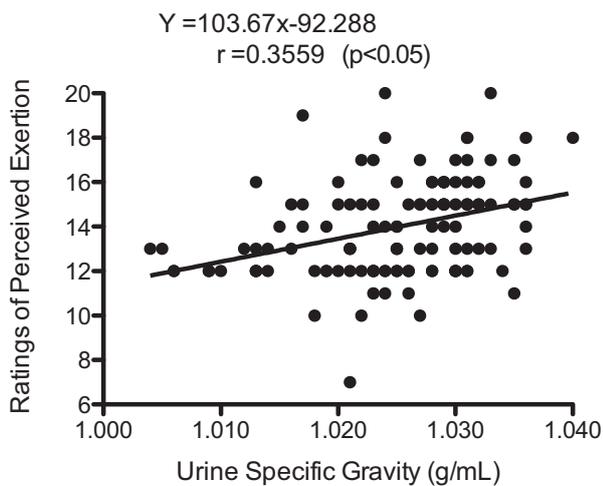


Figure 4. The relationship between urine specific gravity and ratings of perceived exertion.

## DISCUSSION

These findings of the present data provide a novel insight into the hydration status, thermal strain, and associated perceptual responses in collegiate kendo players. Although the environmental conditions in this study were not extreme in an indoor setting, the mean heat stress during kendo practices was within the moderate risk indicated by WBGT. Therefore, the ambient environment during each practice over three consecutive days may have led to a moderate thermal challenge to these players, even when they were accustomed to the indoor setting in the heat.

One notable finding that is concordant with observed typical behaviors in collegiate kendo players was how seemingly dehydrated the players were coming into practices before any practice-based sweat losses were induced (Lue et al., 2010). In the present study, USG was relatively higher before kendo practices of each day, suggesting insufficient hydration status right before kendo practices (Casa et al., 2000). Considering such a condition, these kendo players need to take more of any fluid or water in order to maintain euhydration throughout the day, especially before and during practices. As mentioned above, although inadequate hydration status during practices is also often the case with athletes in other sports (Bergeron et al., 2005 ; Broad et al., 1996), collegiate kendo players should acquire the basic knowledge and procedures about how to maintain euhydration. Given the number of regular breaks, the players certainly had sufficient opportunity to take more fluid than we observed.

Kendo “uniforms”, including a traditional Japanese style of clothing and protective armor, hold heat dissipation, increasing the risk of heat illness secondary to dehydration and hyperthermia. The findings of the present data should be considered by coaches who design practices, particularly when kendo players are not heat acclimatized or when they are unfit in the early season (Johnson et al., 2010). Taken together, the results of this study offer unique insight into kendo-specific physiological and perceptual responses with regard to fluid balance

and thermal strain in collegiate kendo players in an indoor setting in the heat. Such insight will help to give kendo players some strategies for improving insufficient hydration status (Bergeron et al. 2006).

With respect to the assessment of hydration status, there was the limitation of determining urine specific gravity via a spot urine sample. The first morning void or the void after a 12-hour fast has been used as the recommended time to measure urine specific gravity (Aoyagi et al., 1997 ; Armstrong 2005). In the present study, spot urine samples were taken before kendo practices for several reasons : ( i ) It was more convenient for both coaches and athletes, ( ii ) It provided both coaches and athletes with a fundamental idea of prepractice hydration status, and (iii) It offered some basic comparisons for practitioners who may only have the opportunity to evaluate spot urine samples before team practices (Volpe et al., 2009). However, researchers are recommended to use the first morning urine sample to more accurately evaluate status in collegiate kendo athletes.

In conclusion, these findings suggest that most of collegiate kendo players appear to be dehydrated during daily practices, even when the players certainly have sufficient opportunity to take more fluid, which could offer coaches, medical staff, and athletes insights into their hydration status for developing procedures to maintain adequate hydration.

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