

Voluntary, Chronic Dehydration in Adolescent American Football Players

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Abstract: The purpose of the study was to determine whether voluntary acute or chronic dehydration occurs in a male adolescent athletic population during twice-a-day American football practice sessions. We conclude that participants will voluntarily rehydrate themselves between practice sessions and will begin to acclimate within three to four days.

Heat illness appears to be increasingly more common in youth sport participants, perhaps because of the increasing numbers of children and adolescents participating in sports and increased duration and frequency of practice and games. Heat illness is a collective term for exertional illness resulting from exercising in the heat including heat cramps, heat exhaustion, and heat stroke (Armstrong, De Luca, & Hubbard, 1990; Casa, 1999; Rich, 1997). Classically, heat cramps are disabling muscular cramps--most often in the legs or abdominal wall--in an athlete with normal body temperature, clear sensorium, and normal blood pressure (Eichner, 1998). Heat exhaustion is the most common form of heat illness and is defined by the inability to continue exercise in the heat (Lee, 1990). Heatstroke is a medical emergency which can lead to death (Hart et al., 1982) and is usually associated with hypovolemic shock and extreme hyperthermia. Coaches, parents, and athletic trainers should be vigilant in providing precautionary measures including continuous rehydration and in being watchful for signs of heat illnesses.

Adolescents and youth sport participants are at greater risk for heat illness (heat cramps, heat exhaustion, and heat stroke) than adults because they are less efficient thermoregulators (Allen & Overbaugh, 1994). Further, adolescents are more active than adults and spend more active time outdoors (Bar-Or, Dotan, Inbar, Rotshtein, & Zonder, 1980), often in high ambient temperatures and relative humidity increasing thermoregulatory strain and fluid loss. Compared to adults, youths have a larger surface area-to-mass ratio allowing more heat to be absorbed from the environment (Bar-Or, 1989). Youths also have higher metabolic heat production during walking and running, lower cardiac output for any level of oxygen uptake, and a lower ability to perspire (Bar-Or, 1997). Fluid deficits are common as adolescents tend to voluntarily dehydrate while exercising in hot environments even when adequate amounts of fluid are readily available (Bar-Or et al., 1980; Bar-Or et al., 1992).

For ethical reasons, no studies have examined the responses of children's core temperature, other physiological responses, or perceptual functions to hypohydration of more than 3% initial body weight (Bar-Or et al., 1997). The relative ease of ingesting fluids and collecting data has resulted in most research having been conducted on stationary cycle ergometers inside controlled climate environmental chambers (Millard-Stafford, 1992). Research conducted in real life or *in vivo* settings may provide valuable information on adolescents' responses to exercise in the heat. Chronic dehydration may result from voluntary dehydration of adolescent athletes participating in repeated strenuous practice, such as twice-a-day American football practice. Adolescent American football players may be unlikely to rehydrate adequately and may become voluntarily dehydrated between practices on the same day (acute dehydration) or between days of practice (chronic dehydration). The purpose of the study was to determine

whether voluntary acute or chronic dehydration occurs in a male adolescent athletic population during twice-a-day American football practice sessions.

Methods

Participants

Twenty-nine healthy adolescent male American football players 12 - 17 years old (age = 14.5 ± 2.5 yr, height = 174.5 ± 14.5 cm, weight = 92.7 ± 42.1 kg) were recruited from an all boys South Florida preparatory school to volunteer for this study. Males were selected because this is the population participating in tackle football and to reduce the variability of hormone levels and substrate utilization between genders during exercise. Prior to participation on the football team, a physician administered a pre-participation physical examination to all athletes. Health, injury history, and physical activity questionnaires and informed consent forms were read and signed by participants and parents/guardians in compliance with Florida International University's (FIU) Institutional Review Board (IRB) policies. Participants were instructed to continue with regular eating and drinking habits during the two weeks the study was conducted.

Procedures

A familiarization session was conducted in the school's athletic training room during which signed informed consent forms were collected and the primary investigator familiarized participants with testing procedures. All instruments used throughout the study were shown to participants and a demonstration on the use of each instrument was performed. During this session, baseline anthropometric and demographic data were collected. At the conclusion of the familiarization session, participants ($N = 29$, 21 with complete data) were assigned an identification number for confidentiality purposes.

Participants reported to the athletic training room 30 min prior to the beginning of each practice session for data collection. Practice sessions consisted of typical high school American football activities for approximately 2.5 hours for each session during the first two weeks of August in South Florida. Varsity level participants practiced twice a day for four days, with one morning practice session from approximately 9:00--11:30 am and one afternoon practice session from approximately 2:00--4:30 pm. Varsity also held three once-per-day practice sessions, one in the morning and two in the afternoon. Junior varsity level participants practiced for eight days, with one afternoon practice session per day from 2:00--4:30 pm. The first two days of practice for varsity level consisted of shorts only practice sessions (t-shirt, shorts, helmet, socks, and cleats). Following these two days, all practice sessions consisted of the participants wearing full American football equipment (helmet, shoulder pads, t-shirt, padded pants, jersey, socks, and cleats). During each practice session, volume of fluid consumed was recorded during rest breaks regularly scheduled every 15 - 30 min, or as needed. Participants reported to the athletic training room within 30 min of the end of each practice for post-exercise data collection.

Instruments and Testing Procedures

Anthropometric measurements. Body mass was measured to the nearest 0.1 kg using a Tanita BWB-800S digital scale (Tanita Inc., Brooklyn, NY). The scale was placed on a level, hard surface and prior to each session was calibrated using certified weights (Champion Barbells, Dallas, TX). Height was assessed using a metric tape measure (Sears Roebuck & Co., Hoffman Estates, IL) attached to the wall. The height measurements were recorded to the nearest 0.1 cm with each participant barefoot and standing erect with scapulae, buttocks, and calcanei touching the wall.

Hydration status. Hydration status consisted of body mass differences, urine volume, and urine concentration. Body mass was measured as participants disrobed in a private stall with the

scale connected via electronic cord attached to a remote digital display located at the investigator's position outside of the private weighing area. Body mass determinations consisted of towel drying sweat from skin and hair as participants stepped on the scale. Body mass was measured by the investigator using the remote digital display. Throughout practice sessions, the volume of fluid consumed was recorded.

Environmental monitoring. Ambient temperature and relative humidity were measured using a digital temperature humidity monitor (Model PTH8709K, Linseis Inc., Princeton, NJ) calibrated each day prior to the practice sessions using calibration salts and following the manufacturer's instructions. Wind speed was measured using a Kestrel 3000 environmental meter (Richard Paul Russell Limited, Lymington, UK), which is a combined electronic anemometer, thermometer, and hygrometer.

Statistical Analysis

Independent variables were: Day (Day 1 and Day 2) and test (pre-practice and post-practice). The dependent variable was hydration status as measured by body mass. Repeated measures ANOVAs were performed on the dependent variable and when significant interactions existed, tests of simple main effects were performed. Descriptives were calculated for the volume of fluid consumed data. Data were analyzed using the SPSS 11.0 Statistical Package and significance was set at $P < .05$ for all analyses.

Results

Measures of hydration status (body mass) were compared before and after two consecutive American football practice sessions; two practices on one day (Day 1 am and pm) and Day 2 am only. The complete ($n = 12$) body mass data sets (pre- and post-practice for Day 1 am, Day 1 pm, and Day 2 am) were analyzed using repeated measures ANOVA. Body mass data revealed significant ($F_{5,55} = 11.656$, $P \leq .001$, power = 1.00) differences during and between practice sessions. *Post hoc* testing revealed that body mass became significantly ($P = .029$) reduced 1.18% (1.0 kg) during the first morning practice. Body mass was also significantly ($P = .01$) reduced 1.55% (1.3 kg) between the Day 2 post-practice measurement compared to the first measurement (Day 1 pre-am practice). Between the morning and afternoon practices on the first day, body mass was significantly ($P = .001$) increased 1.67% (1.4 kg) however, during that afternoon practice, body mass was again significantly ($P < .001$) reduced 1.30% (1.1 kg). Body mass did not significantly change between days of football practice but, by Day 2 pre-practice, body mass was significantly ($P = .001$) reduced 2.11% (1.8 kg) compared to pre-practice the afternoon prior. Finally, body mass was significantly ($P \leq .001$) reduced 1.15% (1.0 kg) during practice on the second day. Average fluid consumed over the three consecutive practice sessions was 1772.8 ± 158.4 mL per practice (range = 1304.2 – 2093.0 mL). No other data sets were analyzed at this time.

Discussion

Results of this study demonstrate that when allowed to drink water *ad libitum*, adolescents voluntarily chronically dehydrate while participating in twice-a-day American football practice. From the beginning of each practice until its conclusion, every participant demonstrated a decrease in body mass indicating loss of body fluid. Body mass measurements were chosen because this is considered by most researchers to be the gold standard of measuring dehydration (Armstrong, De Luca, & Hubbard, 1990; Casa, 1999; Rich, 1997). During the approximately three hour rest period between morning and afternoon practice sessions body mass data revealed that participants adequately rehydrated and did not become acutely dehydrated. Overall, the pre-afternoon practice body mass measurements exceeded the post-

morning body mass measurements. We expected an increase in body mass overnight with adequate time to rest and digest indicating rehydration. However, when allowed to rest overnight, overall body mass measurements were not significantly different from post afternoon body mass measurements, indicating that participants became chronically dehydrated when they did not adequately rehydrate given an entire night (approximately 15 hours) to rest and consume fluids.

Exercise in the hot, humid conditions during the summer months in South Florida combined with heavy football equipment can lead to dehydration. The American football equipment in this study weighed an average of $6.46 \pm .94$ kg, provided additional weight to carry, and covered large amounts of skin. Athletes have difficulty dissipating heat, as sweat cannot evaporate from covered skin (McCullough & Kenney, 2003). An American football uniform has been shown to significantly increase the risk of dehydration by imposing a heat loss barrier (Matthews, Fox, & Taizi, 1969). Under the American football uniform skin temperature, cutaneous vasodilation, and peripheral blood flow have been demonstrated to increase, reaching near maximal levels. Heart rate and body mass loss also increased as a result of the uniform, which made evaporation and heat loss from the underlying surfaces almost impossible (McCullough & Kenney, 2003). Based upon our findings, the environmental conditions combined with exercise while wearing football equipment, even when fluid was freely available, lead adolescents to dehydrate during a single practice session.

Although our participants had increased body mass between pre morning measurements and pre afternoon measurements, this may not truly represent rehydration. The composition of fluid consumed at rest is extremely important in gastric emptying rate while attempting to rehydrate during a short period of time, as in the current study. We administered a relatively short period (about 3 hours) between practice sessions on the same day, which may have lead participants to feel the need to consume as much fluids and foods as possible during this time. Because of the short amount of time, however, the food and fluids consumed probably had not been absorbed into the bloodstream resulting in extra body mass that did not provide any actual rehydration (Melin et al., 1994; Rehrer, Beckers, Brouns, ten Hoor, & Saris, 1989). Voluntary rehydration typically occurs when ample time is provided for consumption of fluids; however, although our participants did consume food and fluids between practices, the fluids probably had not left the gastrointestinal tract in time to benefit the participants during the afternoon practice session.

Adolescents voluntarily dehydrate even when allowed to drink freely (Bar-Or et al., 1980; Bar-Or et al., 1992; Meyer, Bar-Or, Salsberg, & Passe, 1994; Wilk & Bar-Or, 1996). Voluntary dehydration appears to occur in hot, humid conditions because thirst is an inadequate stimulus for drinking (Ladell, 1965). Although drink composition and flavor have been shown to prevent voluntary dehydration and decrease the risk of dehydration (Meyer et al., 1994), it is important to continuously monitor adolescents' body mass and fluid consumption during exercise since core body temperature can increase $.28^{\circ}$ C for every 1% body weight lost when dehydrated (Bar-Or et al., 1980). When exercising in the heat, adolescents do not adapt as effectively as adults for morphological and physiological reasons (American Academy of Pediatrics, 2000). Adolescents produce more metabolic heat per body mass unit than adults (Astrand, 1952), have a greater surface area to body mass area than adults (American Academy of Pediatrics, 2000), and may have a lower sweating capacity than adults (Bar-Or, 1989), making adolescents more susceptible to dehydration and heat illness than adults. Dehydration results in an almost immediate decrease in physical output (Sawka, 1992). With evaporation being the

primary mechanism of heat dissipation during exercise (American Academy of Pediatrics, 2000), it becomes critical to carefully monitor adolescent athletes when participating in full football equipment. Since adolescents' thirst and thermoregulatory mechanisms are inefficient, voluntary dehydration in adolescents may have more serious consequences when compared to adults.

The dangers of adolescents and dehydration have been clearly defined. While participating in any type of sport, it is very important to prevent dehydration which becomes even more difficult with individuals practicing while wearing American football equipment. The tradition of two practices a day for several consecutive days usually in hot and humid conditions of August creates a very dangerous situation for adolescents in particular. Importantly, athletic trainers must closely monitor every athlete under their care participating during two-a-day practices. With the increased intensity and frequency of practices, even overnight may not be enough to ensure adequate rehydration. Continuous consumption of fluids before, during, and after every practice session is critical to prevent chronic, voluntary dehydration.

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