Original Article

Increased muscle potassium from head down tilt sleeping of healthy subjects during diminished muscular activity

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Abstract

Background and Aim: Periodic fluid redistribution (PFR) with head down tilt (HDT) sleeping produces less fluid loss and more fluid volume. We hypothesized that chronic PFR with HDT sleeping would contribute to and improve electrolyte regulation. Therefore, we studied the potential of regulation of muscle potassium (K^+) and K^+ losses with chronic PFR of HDT sleeping during diminished muscular activity (hypokinesia).

Methods: Studies were conducted on 40 male healthy volunteers. They were equally divided into four groups: Active control subjects (ACS), hypokinetic subjects (HKS), HDT sleeping control subjects (HDTSCS), and HDT sleeping hypokinetic subjects (HDTSHS).

Results: Muscle K^+ increased ($P < 0.05$) and plasma K^+ and K^+ losses decreased ($P < 0.05$) in the HDTSHS group compared to HKS group. In the HKS group, muscle K^+ reduced ($P < 0.05$) and plasma K^+ and K^+ losses increased ($P < 0.05$) compared to preexperimental levels and the values of the other groups. In the HDTSCS group, muscle K^+, plasma K^+, and K^+ losses were affected much less than in the HDTSHS group. Muscle K^+, plasma K^+, and K^+ losses did not change in the ACS group compared to their preexperimental values.

Conclusion: The current study shows that muscle K^+ muscular increases and K^+ losses decrease with chronic PFR of HDT sleeping suggesting regulation of K^+ deposition during diminished activity.

Key words: Muscle potassium, periodic fluid redistribution, potassium regulation, potassium repletion

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INTRODUCTION

Diminished muscular activity (hypokinesia [HK]) is defined as a condition of physical inactivity beyond that is associated with daily deconditioning of skeletomuscular system, the vital organs and systems, and vessels of lower extremities. Diminished activity leads to energy catabolism, body weight losses and reduction of oxidative phosphorylation (OP), mitochondrial density, and adenosine triphosphate (ATP) synthesis.[1-3] Diminished activity decreases muscle mass, blood volume, tissue oxygen supply, and electrolyte deposition.[1-12] To counteract the consequences of HK, preventive measures have been taken without maintaining or regulating electrolytes.[13-18]

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With diminished muscular activity, blood and other body fluids tend to pool into the lower part of the body. Fluid volume shifting into the legs eventually leads to fluid volume deficiency within circulatory system and retention of large fluid volume in the lower part of the body than what is the norm for the lower extremities, results in reduction of blood volume and filling with blood of central vascular bed.[19] Because of fluid shifting in the lower extremities, more fluid volume migrates into the pelvic region and the

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lower half part of the body. Fluid volume which can fit into the venous system of lower part of the body can determine the severity in delivery of fluid volume to upper part of body and thus interstitial fluid and extracellular fluid volume.

The head position down tilt (HDT) sleeping is not analogous to HDT (in humans) and hindlimb suspension (in rats) which is used to simulate weightlessness. Although these situations share a significant increase in HDT thoracic from those fluid volume, there are other factors specific to sleeping in the HDT position. The HDT sleeping contributes to cardiovascular conditioning and total fluid volume expansion. With HDT sleeping, the physiological and biochemical mechanisms are under different control from that of HDT position. The primary mechanisms which drive fluid volume into the regional areas of the body with HDT sleeping are different from the mechanisms with HDT position which shift fluid volume to the upper part of the body, as are many other features specific to HDT sleeping. By contrast to the HDT position, fluid volume is intravascular and intracellular with HDT sleeping and therefore contributes to vascular volume. To differentiate HDT sleeping from other types of HDT position, specific knowledge of the biochemical and physiological reactions with HDT sleeping and HDT position is required.

Periodic fluid redistribution (PFR) is defined as periodic fluid shifting into regional areas of the body beyond that of fluid redistribution (FR) in other situations. PFR involves reprogramming vital organs and contributes to aerobic metabolism, hypervolemia and tissue perfusion, and reduces blood and interstitial fluid pressure. PFR contributes to anabolism and synthesis of ATP, OP, and mitochondria density, enhances glycogen production and tissue oxygen supply, and increase muscle mass and cell mass.

With periodic shifting of blood and other body fluids toward the head, the brain does not interpret its blood supply as excess fluid volume, but as simple FR. Responding to this misperception, the brain does not signal the kidneys and other organs to reduce blood volume and other body fluids. The systems somehow tend to adapt to PFR, while periodic fluid shifting to the regional areas of the body expands fluid volume. Cardiopulmonary baroreceptors do not stretch and do not interpret this as excess fluid volume and therefore do not stimulate the body to reduce fluid volume. This process show electrolyte losses contributing to electrolyte repletion. Thus, PFR which moves fluid away from the lower part of the body into regional areas of the body may be one solution for fluid volume expansion and electrolyte regulation[20] during diminished muscular activity.

Chronic fluid shifting to lower part of the body leads to fluid deficiency within the circulatory system. Fluid deficiency makes metabolism of electrolyte to dysfunction. Chronic PFR with HDT sleeping counteracts the consequences of fluid shifting to Chronic lower part of sleeping the body and consequently fluid deficiency. PFR with HDT has profound multi-system effects on the human body which include electrolyte regulation, The magnitude with HDT sleeping of these effects generally increases as duration of PFR increases. Extending the time of treatment of PFR with HDT sleeping will significantly improve electrolyte metabolism more than any other treatment endeavor to date.

We hypothesize that chronic PFR with HDT sleeping would make electrolyte metabolism to work much better. Therefore, to determine the potential of regulation of K^+ with chronic PFR of HDT sleeping, we measured muscular K^+ in muscle, plasma, urine, and feces during diminished activity.

MATERIALS AND METHODS

The investigation conformed to the principles of the declaration of Helsinki. All the study protocols were reviewed and approved by the Committee for the Protection of Human Subjects of the Institutional Review Board. All the subjects received verbal and written explanations of the experimental and test protocols prior to providing written informed consent. Among the subjects, there were no medical problems and none of the subjects were under any drug therapy which could have interfered with potassium metabolism. There were no drop-outs in the study. Financial incentives relative to average monthly earnings were used to encourage compliance with the protocol of the study. Forty physically healthy male subjects, 23.8 ± 4.4 years of age were chosen as subjects. All the subjects ran an average distance of 10.0 ± 2.2 km/day at a speed of 10.1 ± 1.1 km/h for 3–5 years. The subjects had a body weight of 76.0 ± 4.2 kg and peak oxygen uptake of 48.0 ± 3.3 mL/kg/min. In preexperimental period of 390-days, subjects ran an average distance of 10.1 ± 1.6 km/day at a speed of 10.0 ± 1.1 km/h.

Random assignment of subjects into four groups was done randomly by an assistant, blinded from the recruitment and treatment procedures, and a concealed method was used.

Group 1: Ten subjects ran an average distance of 10.1 ± 1.3 km/day. They were assigned to the active control subjects (ACS) group. Group 2: Ten subjects walked an average distance of 3.5 ± 0.3 km/day. They were assigned to the hypokinetic subjects (HKS) group. Group 3: Ten subjects ran an average distance of 10.2 ± 1.4 km/day and were subjected to HDT sleeping.

They were assigned to the HDT sleeping control subjects (HDTSCS) group. Group 4: Ten subjects walked an average distance of 3.5 ± 0.3 km/day and were subjected to HDT sleeping (HDTSHS). They were assigned to the PFR hypokinetic subjects group.

Protocol

The investigation consisted of a 390-day preexperimental period and a 364-day experimental period. Diets were served as a 7-day menu rotation. The meals were all prepared under standard conditions in a research kitchen. Mean daily energy consumption of the metabolic diet was 3533 ± 560, 2920 ± 320, 3535 ± 564, and 3025 ± 345 standard deviation (SD) kcal, and the mean daily consumption of K^+ was 83.8 ± 1.2, 83.7 ± 1.5, 83.6 ± 1.4, and 83.7 ± 1.3 SD mmol for the ACS, HKS, HDTSCS, and HDTSHS groups, respectively. The subjects were housed in a facility in which the temperature, humidity, activities, and dietary intakes were monitored 24 h/day and 7 days/week.

Simulation of diminished muscular activity

To simulate diminished muscular activity, the number of kilometers walking per day was restricted to an average of 3.5 ± 0.3 km/day and was monitored daily by an accelerometer. The activities allowed were those which approximated the normal routines of the hypokinetic individuals. The subjects were allowed to walk to the dining rooms, lavatories, and different laboratories where the tests were given. Climbing stairs and other activities which required greater efforts were not allowed. The subjects were mobile and were not allowed outside the laboratory grounds so that the level of diminished muscular activity was remained relatively constant and had ability for easy monitoring.

Simulation of periodic fluid redistribution by sleeping in head down tilt position

To simulate PFR, the subjects slept in bed without a pillow at a HDT position of −6° to −30°. HDT sleeping increased progressively from −6° to −30° by −2° every 34–51 days. For the rest of the experimental period, the HDT sleeping subjects were placed at a best degree of HDT position. In the HDT position of −6° to −30°, the subjects remained for at least 8–10 h/day. The procedures were determined from a preliminary experimentation and after the ability of subjects to adapt to −2° to −30° of HDT position was established. The individual differences of the metabolic, biochemical, physiological, cardiovascular, endocrine, and renal reactions of the subjects and their clinical symptom and sensitivity to various degrees of HDT sleeping were taken into account. The schedule HDT sleeping was periodically changed to conform to requirements of adaptational ability of subjects. To ensure the comfort of volunteers in HDT position, the range of −6° to −30° was modified from time to time as required.

Blood, urinary, and fecal sample collection

To accommodate inter-individual differences in bowel habits, urine and feces were analyzed daily and were pooled to form 6-day composites, while blood samples were assayed every 6-day during the preexperimental and the experimental period. The 6-day (consecutive days) pooled samples were collected. Blood samples were collected with disposable polypropylene syringes. Following overnight fasting for about 8–9 h, venous samples of blood were taken at rest and before any meal. Blood samples were drawn under the same condition between 8.00 and 9.00 a.m., without a venous stasis and after the subjects had been sitting for about 30 min. The sample volume was 7–9 mL. To obtain plasma, blood samples were collected in heparinized ice-chilled tubes and were centrifuged immediately at 10.000 ×*g* for 3 min at room temperature and separated using glass capillary pipettes, which was washed in hydrochloric acid and deionized distilled water. Immediately after centrifugation, plasma samples were frozen on dry ice and were stored at −20°C until analyses were conducted for plasma K^+. 24 h urine samples were stored at −4°C until needed for K^+ analysis. To ensure complete 24 h urine collections, the creatinine loss was measured by a colorimetric method using Jaffe's reaction. Feces were collected in plastic bags, weighed, and stored at −20°C for K^+ analysis. Fecal samples were dried-ashed in a muffle furnace at 600°C overnight. Ashed samples were dissolved in 5% nitric acid. To ensure complete feces recovery, polyethylene glycol was used as a marker.

Muscle preparations, potassium extraction, and analysis

Muscle biopsies were performed by a percutaneous needle technique[21] under local anesthesia. Specimens were taken from the lateral portion of the quadriceps femoris muscle, 12–18 cm proximal to the knee. The muscle (mean weight 14.0 mg) was placed on a piece of quartz glass and with nonmetal tweezers carefully dissected free from all visible fat and connective tissue. Traces of blood were wiped off by rolling the specimens on the piece of quartz glass. Muscle was then placed on a platinum hook and dried in an oven at 110°C to constant weight, extracted in 1 mL of petroleum ether for 2 h and dried to constant weight, and fat-free dry solids (FFDS) weight was calculated. Potassium was extracted from muscle by treatment with 250 μL 2.5 M HNO_3 for 24 h. From each sample, 100 μL of supernatant was diluted to 10 mL with 0.25% $SrCl_2$ and analysis of potassium in muscle was performed using a Flame Emission Spectrophotometer on a Perkin-Elmer 320 Model, Perkin-Elmer Corp., Norwalk, CT. The results

obtained on muscle potassium content were calculated in mmol/100 g^{-1} FFDS.

Potassium measurements

Samples were analyzed in duplicate, and appropriate standards were used for the measurements. The muscle K^+ content, plasma K^+ level, and K^+ loss in feces and urine were measured by a Flame Emission Spectrophotometer of a Perkin-Elmer 320 Model, Perkin-Elmer Corp., Norwalk, CT.

Data analyses

A two-way interaction (treatment [4 levels] by days [6 levels]) analysis of variance (ANOVA) was used to is affected determine whether muscle K^+ regulation during PFR of HDT sleeping. The ANOVAs with repeated measures of two-way interaction (treatment and days, preexperimental and experimental levels, hypokinetic and HDT sleeping hypokinetic groups of subjects, hypokinetic and control groups of subjects) was used. The ANOVAs for each time point measurements were used. The statistical analysis of the results obtained was performed with GraphPad Prism statistical software (GraphPad Software Inc., La Jolla, CA). The level of significance was set at $P < 0.05$. The results obtained were reported as mean ± SD.

RESULTS

Initially, subjects were reported symptoms analogous to those of HDT position. Most symptoms were typical to HDT sleeping [Table 1]. Symptoms shown mostly at −8° to −12° of HDT sleeping. Symptoms were more pronounced in the HDTSCS group than the HDTSHS group. The severity of symptoms was different among subjects of the same group. At −14° to −18° of HDT, sleeping subjects had less symptoms. The greatest adaptation to HDT sleeping was shown at −26° to −30°. The HDTSHS group had gained height, power, and strength compared to HDTSCS group. After completion of the study, the subjects with HDT sleeping decided to continue this regime. However, they have reported some symptoms, when engaged in different activities.

Table 1: Clinical reactions of healthy subjects to HDT sleeping position

Puffiness in the face
Tachycardia
Loud heart sounds
Ventricular extrasystoles
Arrhythmias
Tinnitus in the left and more in the right ear
Feeling of fullness (pressure) or stuffiness in the left ear and more in the right ear
Deep vein symptoms in the left and more in the right leg
Pain in the left and more in the right foot
Pain in the left and more in the right hand
Cold sensation of the right hand
Pain in the calcaneal tendon region (Achilles) in the left and more in the right leg
Upper body back skin itching and discoloration
Sputum production clearance

HDT: Head down tilt

At preexperimental period, muscle K^+ decreased and plasma K^+ and K^+ losses increased in the HDTSHS group and the HDTSCS group. However, as the duration of preexperimental period increased and the subjects were adjusted to HDT sleeping of chronic PFR, muscle K^+ increased and plasma K^+ and K^+ losses decreased [Table 2]. Muscle K^+, plasma K^+, and K^+ losses in urine and feces remained stable in the control and the hypokinetic groups of subjects without HDT sleeping treatment [Table 2].

In the experimental period, muscle K^+ increased ($P < 0.05$) and plasma K^+ and K^+ losses of urine and feces decreased ($P < 0.05$) in the HDTSHS group compared to the HKS group [Table 2]. In the HKS group without HDT sleeping, muscle K^+ decreased ($P < 0.05$) and plasma K^+ and K^+ losses increased ($P < 0.05$) compared to the preexperimental levels and the values of the other groups [Table 2]. Muscle K^+ and plasma K^+ and K^+ losses in the HDTSCS group benefited much less than in the HDTSHS group [Table 2]. In the ACS group, muscle K^+, plasma K^+, and K^+ losses in urine and faces did not change compared to their preexperimental values [Table 2].

DISCUSSION

This study shows muscle K^+ repletion with chronic PFR of HDT sleeping. Evidently, HDT sleeping of PFR is a potent stimulus for the protection and increase of muscle K^+ as was shown by the significant differences between the HDTSHS group and other groups. HDT sleeping of chronic PFR may act as a potent stimulus of K^+ repletion because muscle K^+ cannot increase with fluid shifting to the head unless it is deposited. The muscle K^+ repletion suggest that HDT sleeping of PFR may protect and increase muscle K^+. With chronic PFR of HDT sleeping, K^+ is taken up for deposition and used by the body that in turn protects net muscle K^+. The decreased plasma K^+ suggests K^+ regulation because plasma K^+ cannot decrease with muscle K^+ repletion unless it is regulated. The reduced plasma K^+ indicates K^+ deposition because plasma K^+ cannot decrease in K^+ replete muscle except if K^+ is deposited. The decreased K^+ losses indicate K^+ regulation, because K^+ losses cannot reduce with K^+ replete muscle except when K^+ is regulated. Lower K^+ losses suggest that the more K^+ is not sensed as excessive K^+ because K^+ losses cannot decrease with

Table 2: Potassium in urine and feces, plasma potassium and muscle potassium measured in the control and the hypokinetic groups, and the HDT sleeping control and the HDT sleeping hypokinetic groups during preexperimental and experimental period

Experimental period in days	Potassium			
	Urine (mmol/days)	Feces (mmol/days)	Plasma (mmol/L)	Muscle (mmol/100/g^{l} FFDS)
ACS (*n*=10)				
Average values preexperimental	73.6±11.3	19.5±2.0	4.15±0.02	34.15±3.40
60th	73.1±10.0	19.0±2.2	4.11±0.03	34.28±3.28
120th	73.7±11.5	18.8±2.0	4.08±0.05	34.36±2.30
180th	73.9±11.2	19.3±2.1	4.13±0.03	34.30±3.43
240th	72.8±10.3	18.6±2.0	4.08±0.04	34.37±2.39
300th	73.3±11.4	19.2±2.2	4.07±0.05	34.45±3.28
364th	72.5±10.2	18.8±2.0	4.13±0.03	34.56±2.37
HKS (*n*=10)				
Average values preexperimental	73.3±10.3	19.3±2.2	4.13±0.02	34.13±3.33
60th	90.7±11.3*,†	24.3±3.0*,†	4.50±0.03*,†	31.00±4.32*,†
120th	91.8±10.5*,†	23.5±3.3*,†	4.48±0.04*,†	31.13±3.35*,†
180th	93.4±12.4*,†	26.4±4.5*,†	4.55±0.02*,†	30.38±3.31*,†
240th	94.0±10.6*,†	25.3±3.3*,†	4.50±0.04*,†	30.65±3.40*,†
300th	107.0±10.4*,†	29.0±4.4*,†	4.70±0.02*,†	27.75±4.38*,†
364th	105.8±11.5*,†	28.2±3.5*,†	4.66±0.03*,†	28.06±3.31*,†
HDTSCS (*n*=10)				
Average values preexperimental	77.5±13.0	20.5±2.0	4.25±0.01	33.70±3.50
60th	75.8±11.4	20.0±3.0	4.20±0.04	34.43±3.35
120th	76.6±12.0	20.5±4.0	4.21±0.02	34.37±4.41
180th	73.6±10.5	19.0±3.3	4.18±0.03	34.85±3.44
240th	74.3±11.3	19.7±4.0	4.19±0.04	34.75±4.38
300th	69.1±12.0	18.0±3.5	4.14±0.03	36.46±4.35
364th	70.5±11.5	18.5±4.3	4.15±0.03	36.38±3.40
HDTSHS (*n*=10)				
Average values preexperimental	77.3±10.3	20.3±2.2	4.25±0.02	33.68±3.44
60th	66.0±12.3^{+}	17.0±3.0^{+}	4.16±0.02^{+}	35.10±3.40^{+}
120th	67.6±10.5^{+}	17.5±4.2^{+}	4.17±0.03^{+}	34.82±3.38^{+}
180th	65.2±11.3^{+}	16.8±3.3^{+}	4.12±0.04^{+}	35.98±4.41^{+}
240th	66.3±12.4^{+}	17.0±4.0^{+}	4.14±0.03^{+}	35.90±3.38^{+}
300th	61.7±11.5^{+}	15.8±3.2^{+}	3.95±0.03^{+}	37.70±4.40^{+}
364th	62.1±12.3^{+}	16.0±3.0^{+}	4.01±0.04^{+}	37.63±3.39^{+}

All values were expressed as mean±SD. $^{\dagger}P$<0.05 significant differences between the preexperimental and experimental period values, $^{*}P$<0.05 significant differences between the control and the hypokinetic groups of subjects, ^{+}P<0.05 significant differences between the hypokinetic and the HDT sleeping hypokinetic groups of subjects. FFDS: Fat-free dry solids, HDTSHS: HDT sleeping hypokinetic subjects, HDTSCS: HDT sleeping control subjects, HKS: Hypokinetic subjects, ACS: Active control subjects, SD: Standard deviation, HDT: Head down tilt

K^+ replete muscle unless the more K^+ is sensed as simple K^+ redistribution.[4-12]

When the subjects adapted to PFR of HDT sleeping, they continue to show higher muscle K^+ and lower plasma K^+ and K^+ losses, while the subjects with pure HK alone continue to show lower muscle K^+ and higher plasma K^+ and K^+ losses. In the HDTSHS group with muscle K^+ repletion, plasma K^+ and K^+ losses decreased, while in the HKS group with muscle K^+ depletion, plasma K^+ and K^+ losses increased. In the HDTSHS group, the K^+ control mechanisms may be different from those in the HKS group. Muscle electrolyte repletion is shown by lower than high plasma and electrolyte losses and electrolyte deficiency by higher than lower plasma and electrolyte losses.[4-12] The decrease of K^+ losses with K^+ repleted muscle and the increase of K^+ losses with K^+ depleted muscle suggest different regulation mechanisms. Some studies have shown that fluid volume expansion with fluid and salt supplementation in small doses may contribute to the reduction of electrolyte losses because fluid volume expansion is sensed as PFR and excretion mechanisms are not activated.[22-27] The reduction of fluid loss reflects the dissociation of PFR with the increases in venous return and central volume, which inhibits cardiopulmonary baroreceptors. It is generally believed that expansion of vascular volume with chronic PFR of HDT sleeping makes metabolism of K^+ to work better. The kidneys and endocrine systems adjust electrolyte regulating hormones to reduce electrolyte losses. Later of adaptation to PFR of HDT sleeping and/or expansion of fluid volume, kidneys and endocrine glands establish new "normal" fluid and electrolyte values and hormone levels appropriate for chronic PFR of HDT sleeping and fluid volume expansion. Some studies[28-32] have

shown that fluid volume expansion with fluid and salt supplementation in small doses may be used to counteract the consequences of diminished muscular activity and increased tissue electrolytes. Thus, chronic PFR with HDT sleeping may increase muscle K^+ and decrease K^+ losses during diminished muscular activity.

The control subjects with PFR of HDT sleeping fail to show significant difference compared to other groups; this is because the HDTSCS group was physically active. Physical exercise may act more as stressor rather than as stimulus to PFR of HDT sleeping. Similarly, studies have shown that physical exercise may act more as stressor than as a stimulus.[13] Physical activity may affect the ability of the body to adapt to fluid volume expansion because the higher physical activity, the lower adaptability of the body to fluid volume expansion.[28-32] Fluid volume expansion is neither intravascular nor intracellular fluid and, therefore, does not contribute to vascular volume. Some studies[28-32] have shown that physical activity may not result in more fluid volume and tissue electrolytes. Physical activity that moves fluid to the lower part of the body may determine the severity in delivery of fluid to the upper part of the body and thus extracellular and interstitial fluid volume. The physical activity may affect PFR of HDT sleeping as shown by the minor changes in K^+ regulation in the HDTSCS group compared to the HDTSHS group. Therefore, one would not notice K^+ regulation improvements in the HDTSCS group as in the HDTSHS group. Physical activity may play a vital part in the protection and deposition of K^+ as was shown by the no changes in muscle K^+ and K^+ losses in the ACS group compared to HKS group. PFR of HDT sleeping even with physical activity is a powerful stimulus for K^+ regulation provided that PFR of HDT sleeping is used over longer period of time than the time required without exercise.

It is evident that periodic fluid shifting to the upper part of the body with HDT sleeping increases muscle K^+ and reduces plasma K^+ and K^+ losses. This indicates a common conception that HDT sleeping with PFR is important for K^+ metabolism regulation under diminished muscular activity. This adds an important contribution to K^+ metabolism because people experience muscle K^+ deficiency under diminished activity.[4-12] Chronic fluid volume shifting from lower to the upper part of the body with HDT sleeping may be more of stimulus than stressor of K^+ metabolism adaptation. Chronic PFR with HDT sleeping may increase the ability of the body to produce more interstitial and extracellular fluid volume and thus total fluid volume. Expansion of fluid volume with chronic PFR of HDT sleeping may affect K^+ metabolism adaptation. Because muscle K^+ increases and plasma K^+ and K^+ losses decrease as the duration of adaptation to chronic PFR with HDT sleeping increases, suggests that the higher K^+ metabolism adaptation to PFR with HDT sleeping, the greater K^+ deposition. The mechanism by which chronic PFR with HDT sleeping improves K^+ metabolism adaptation to diminished muscular activity has not been established yet. However, the hypokinetic volunteers who were subjected to chronic PFR with HDT sleeping may have experienced a less labile and more responsive K^+ metabolism adaptation.

The chronic PFR with HDT sleeping of different degrees is also used to treat diseased organs and systems. The effects of chronic PFR with HDT sleeping on healthy and diseased humans have demonstrated a potent multiorgan system functional benefit. Chronic PFR with HDT sleeping triggers a chain of events to restore and reregulate that force body organs and systems. The following summary of benefits of chronic PFR with HDT sleeping is derived from unpublished studies by Fedorov *et al*. Chronic PFR with HDT sleeping increases total fluid volume and regulates body organs and systems, particularly the vital organs and systems and make them to work better. With PFR of HDT sleeping, the cardiovascular, endocrine, renal, metabolic, and immune systems are regulated. Chronic PFR with HDT sleeping triggers diseased organs and systems to regenerate. Chronic PFR with HDT sleeping can improve spinal cord and brain functions and help recover lost capabilities to disease and trauma. With PFR of HDT sleeping, intracranial pressure decreases. With HDT sleeping of chronic PFR, there is an increase in cell mass, muscle mass, and bone mass. Principal symptoms of arthritis and osteoarthritis are diminished with PFR of HDT sleeping. PFR of HDT sleeping has the potential to make immune system permanently active, repair damage tissue, increase heart muscles, and restore heart and kidney insufficiency, and prevent myocardial infractions and stroke. PFR with HDT sleeping reduces cardiovascular diseases and lung infections. Chronic PFR of HDT sleeping increases venous return and cardiac output, left ventricular volume, coronary arteries size, and regulates blood pressure. With chronic PFR and HDT sleeping increases venous return and cardiac output, left ventricular volume, coronary arteries size, and regulates blood pressure. Interstitial fluid pressure in different diseases such as in solid malignancies and inflammation as in osteoarthritis may be reduced by chronic PFR with HDT sleeping. Chronic PFR with HDT sleeping can have an impact on the signaling pathways that mediates cancer. Chronic PFR with HDT sleeping affects the way drugs are taken up by the body, bacterial cell membranes become thinner and more permeable, increasing the effectiveness of antibiotics. HDT sleeping with chronic PFR makes it easier to pass stools and force hemorrhoids to shrink. HDT sleeping with chronic PFR has the potential to increase longevity by 30–40% and functional ability and strength of the antigravity muscles.

Periodic fluid redistribution and head down tilt sleeping contraindications/precautions

Contraindications/precautions should be taken into account prior to commencing chronic PFR with HDT sleeping treatment.

Chronic PFR with HDT sleeping has not been tolerated with physical exercises.

Avoid straightaway using chronic PFR with higher degrees of HDT sleeping to prevent sickness.

Prepare the chronic patient by giving a clear explanation of the treatment with chronic PFR and HDT sleeping.

Minimize distress and inform the patient about the procedure with chronic PFR and HDT sleeping.

Increase adaptation of patient to chronic PFR with HDT sleeping positions.

Obtain consent from the patient to confirm that the patient is willing to undertake chronic PFR with HDT sleeping treatment.

Examine the patient's heart to ensure no cardiovascular illness is present prior to the treatment with chronic PFR and HDT sleeping.

CONCLUSION

Significant differences in K^+ metabolism was found between the HKS who were submitted to chronic PFR of HDT sleeping and those who were not. The different mechanisms of K^+ metabolism regulation could have contributed to higher muscle K^+ and lower K^+ losses with chronic PFR of HDT sleeping and the lower muscle K^+ and the higher K^+ losses without it. The chronic PFR with HDT sleeping is a potent stimulus for the protection and improvement of K^+ metabolism during diminished muscular activity. The underling mechanisms, however, by which chronic PFR with HDT sleeping contributes to and/or improves K^+ metabolism regulation are yet to be established. Further studies are needed to determine how the body uses the mechanisms of PFR with HDT sleeping to counteract the consequences of fluid shifting to lower parts of the body to benefit electrolyte regulation. In conclusion, chronic PFR with HDT sleeping may be used to efficiently regulate muscle K^+ metabolism during diminished muscular activity.

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Conflicts of interest

There are no conflicts of interest.

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