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Vitamin D3 Status and the Cardiovascular Response to Head Down Flexion in Healthy Adults

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ABSTRACT

Objectives: The primary aim of this study was to elucidate relationships linking vitamin D consumption and the vestibulo-sympathetic reflex (VSR) by exploring the associations between self-reported vitamin D consumption and the cardiovascular responses to head-down flexion (HDF), a maneuver known to activate the vestibulo-sympathetic response.

Background: During orthostasis, the body attempts to maintain cerebral blood flow, thereby avoiding syncope. Orthostatic intolerance, the inability to withstand postural changes, occurs when cardiac output is not maintained during orthostasis and is highlighted by symptoms including lightheadedness, impaired cognition, loss of balance, low blood pressure, and syncope. The cardiovascular and vestibular systems work in tandem to sustain cardiac output via the VSR. Due to its dependency on proper cardiovascular and vestibular function, the VSR may be vulnerable to nutrient deficiencies that impair these systems. Vitamin D, a fat-soluble vitamin, is critical to endothelial and smooth muscle function, calcium and phosphate metabolism, and vestibular otolith development and function. Though positive relationships between vitamin D serum levels and cardiovascular and vestibular health have been made, to date no data examine vitamin D status regarding the VSR. We investigated the relationship between vitamin D consumption and the VSR during HDF in healthy adults, hypothesizing that vitamin D consumption would be positively associated with the vestibulo-sympathetic reflex.

Methods: Vitamin D consumption of 31 participants was measured using a food frequency questionnaire. The incidence of orthostatic intolerance within the study group was assessed using the Orthostatic Hypotension Questionnaire. Radial applanation tonometry-derived augmentation indices were used to assess arterial stiffness. Popliteal blood flow velocity and popliteal artery diameter were measured via ultrasound, and popliteal blood flow and popliteal vascular conductance were calculated to assess lower limb cardiovascular responses during HDF. A three-lead electrocardiogram was used to determine heart rate.

Results: Age, sex, and change in head angle were used as covariates throughout all analyses. Mean vitamin D consumption was 3.36 ± 2.39 mcg within the study group. The mean orthostatic tolerance score was 6.18 ± 8.16. Systolic blood pressure and MAP decreased by 2.26±1.46 mmHg ($P<0.05$) and 1.06 ± 1.49 mmHg ($P<0.05$), respectively, during HDF. Heart rate decreased by 0.59 ± 0.10 bpm during HDF. Head-down flexion also decreased augmentation index by 7.6% ($P < 0.05$), popliteal blood velocity by 0.87 cm/s ($P < 0.05$), and popliteal blood flow by 10 ml/min during HDF. No other cardiovascular findings were significant. Pearson's correlations failed to detect significant relationships between vitamin D consumption and cardiovascular responses to HDF.

Conclusions: This study aimed to identify novel relationships between vitamin D consumption and the vestibulo-sympathetic reflex during head-down flexion. Consistent with previous work regarding the VSR, upper and lower body responses were observed, including decreases in blood pressure and lower limb blood flow and blood flow velocity. However, the current study did not identify significant relationships between vitamin D consumption and cardiovascular responses to head-down flexion. Participants' average reported vitamin D intake was far below the National Institute of Health's daily recommended intake of 15mcg. It is thus reasonable to assume participants did not consume enough vitamin D to influence cardiovascular function. Lastly, our sample may not have achieved sufficient change in head angle to elicit the VSR.

Follow-up studies should examine vitamin D status objectively, establish a minimum change in head angle to ensure excitation of the VSR, and utilize vitamin D sufficient and insufficient groups to contrast the vestibulo-sympathetic reflex during head-down flexion.

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ABBREVIATIONS

AD: Popliteal artery diameter

AIx: Augmentation index

ANS: Autonomic nervous system

BMI: Body mass index

CV: Cardiovascular

DBP: Diastolic blood pressure

ECG: Electrocardiogram

FFQ: Food frequency questionnaire

ΔHeadAng: Change in head angle

HR: Heart rate

HDF: Head-down neck flexion

MAP: Mean arterial pressure

MSNA: Muscle sympathetic nerve activity

OHQ: Orthostatic hypotension questionnaire

OTS: Orthostatic tolerance score

PBF: Popliteal blood flow

PBV: Popliteal blood velocity

PVC: Popliteal vasculature conductance

PWV: Pulse wave velocity

SBP: Systolic blood pressure

VitD Score: Vitamin D score

VSR: Vestibulo-sympathetic reflex

Introduction

During orthostasis (i.e., maintenance of blood pressure when standing), roughly 450ml to 550ml of one's blood volume is transferred caudally, resulting in lower limb venous pooling (Figueroa et al., 2010). This fluid shift decreases venous return, reducing blood pressure and cardiac output, a condition known as orthostatic hypotension (Bradley, 2003). Though orthostatic hypotension increases with age, it may occur throughout all life stages and is exacerbated by preexisting conditions, including cardiovascular disease, vestibular disorders, and chronic malnourishment (Figueroa et al., 2010). During bouts of orthostatic hypotension, cerebral hypoperfusion occurs, and the risk of lightheadedness, dizziness, and syncope increases due to the insult to cerebral oxygenation (Stewart, 2013).

During initial orthostasis, skeletal muscles in the legs contract, increasing venous return and reducing lower limb pooling (Bradley, 2003). While effective, the muscle pump mechanism is finite; thus, a downstream fluid shift still occurs. This fluid shift unloads aortic and carotid stretch receptors (i.e., baroreceptors), which send signals to the brain to activate the autonomic nervous system, resulting in increased vasoconstriction, cardiac contractility, and heart rate (Lee et al., 2001; Stewart, 2013). Though these feedback mechanisms aim to protect against orthostatic hypotension, cerebral blood pressure has been shown to drop by 20mmHg resulting in a 12% decrease in cerebral blood flow during orthostasis, regardless of skeletal muscle or baroreceptor activation (Stewart, 2013). The muscle pump and baroreceptor's inability to maintain blood pressure and blood flow during position changes have been attributed to three physiological limitations of these systems 1.) increased venous return via lower limb muscle contraction is finite 2.) the baroreceptor reflex must first detect a disturbance in blood flow (e.g., decreased pressure via fluid shifts) and 3.) the nerve pathway connecting the baroreceptors to the brain are unmyelinated resulting in increased latency (Yates, 2014). These limitations have led to a growing body of research regarding a feed-forward mechanism for maintaining blood pressure and systemic perfusion during orthostasis, known as the vestibulo-sympathetic reflex.

The vestibulo-sympathetic reflex (VSR) was first implicated in blood pressure management during orthostasis by Reis and Ledoux (1987) and has since been shown to protect against orthostatic hypotension, especially during early orthostasis (i.e., before standing, Aoki et al., 2012; Yates, 2014; Park et al., 2017; Villar & Hughson, 2013). VSR-induced sympathetic excitation aids in blood pressure and blood flow regulation by increasing heart rate and stimulating lower limb veno- and vasoconstriction (Shortt & Ray, 1997; Ray, 2000; Lee et al., 2001). Within the inner ear are two gravity-sensitive otolith organs, the utriculus and the sacculus, responsible for detecting movement (Purves et al., 2001). When motion is detected, sensory information is transmitted from the otolith organs to the brainstem via the vestibular nerve, resulting in sympathetic nerve activation (Yates et al., 2014; Jauregui-Renaud et al., 2003).

Due to its connection to the autonomic nervous system (ANS), the VSR has an attenuated latency and is critical in sustaining blood pressure during early orthostasis (Kaufmann et al., 2002). In animal models, the transection of the vestibular nerve significantly reduced lower limb blood flow and vascular resistance during a nose-up tilt, a protocol dependent on otolith activation (Doba and Reis, 1974; Jian et al., 1999). In humans, head-down flexion (HDF), a maneuver that activates the otolith organs while controlling for baroreflex activation, significantly increases sympathetic nerve activity of the vascular smooth muscle simultaneous to a parasympathetic withdrawal (Ray, 2000; Lawerence et al., 2008; Yates, 2014). Collectively, these findings indicate that the VSR is not dependent on fluid shifts. Instead, it affects autonomic modulations of the cardiovascular system during position changes via otolith signaling. However, by design, the VSR is dependent on proper otolith and cardiovascular health and thus may be vulnerable to nutrient deficiencies that threaten these systems.

Vitamin D is a fat-soluble vitamin essential to proper physiology, including maintaining skeletal integrity, immune system regulation, and electrolyte balances (Parva et al., 2018). The primary source of vitamin D is direct exposure to ultraviolet-B light (i.e., sunlight), though alternate sources include vitamin D-rich foods such as fortified foods (e.g., cow and plant-based milk, ready-to-eat cereals), fatty fish (e.g., trout or salmon), and vitamin D supplementation (Chang and Lee, 2019). Though sources of vitamin D are plentiful, roughly 40% of U.S. adults aged 20 years and older are vitamin D deficient (i.e., <50nmol/L; Parva et al., 2018). Epidemiological studies have indicated that vitamin D deficiency is associated with an increased risk of stroke, myocardial infarction, and hypertension in the general population (Beveridge and Witham, 2012). Additionally, vitamin D deficiency has been correlated with an increased pulse wave velocity (PWV) and augmentation index (AIx), thus implicating an increase in arterial stiffness and endothelial dysfunction in the face of low serum vitamin D (Mheid et al., 2011).

Further, vitamin D is crucial in regulating electrolyte levels, specifically calcium and phosphate, two nutrients paramount to maintaining otolith organ health. In animal models, vitamin D receptor-deficient mice developed calcium imbalances resulting in abnormal otolith development and significantly reduced posture control (Sanyelbhaa and Sanyelbhaa, 2014). Similarly, vitamin D deficiency in humans has been implicated in abnormal otolith development resulting in otolith dysfunction and an increased risk of vestibular diseases such as benign paroxysmal positional vertigo and Meniere's disease (Wu et al., 2019; Sheikzadeh et al. 2016; Burt et al., 2016; Boersma et al., 2012). Therefore, an abnormal vitamin D status may impair cardiovascular and otolith function resulting in a reduced vestibulo-sympathetic reflex during early orthostasis, thereby increasing the risk of cerebral hypoperfusion and syncope; however, no data exists regarding this topic.

This pilot study examined the relationship between daily vitamin D consumption and the vestibulo-sympathetic reflex by measuring and comparing vitamin D consumption and the cardiovascular responses to head-down flexion in healthy young adults (Fig. 1). We hypothesized that higher levels of vitamin D intake would enhance cardiovascular responses to head-down flexion, thereby indicated an increased vestibulo-sympathetic reflex.

1. Methods

1.1 Subjects

Thirty-one adults (17 men and 14 women) volunteered for this study. At the time of data collection, all participants were between 18 and 65 years of age, normotensive, and free from known cardiovascular or vestibular disorders. All data collection occurred during a single visit to the Human Performance Laboratory, Syracuse University, Syracuse, New York. The study protocol was submitted to and approved by the Institutional Review Board at Syracuse University (IRB protocol#21-124). Before data collection, verbal and written explanations of the experimental procedures and potential risks were given, and each participant signed an information and consent form. Participants were instructed to undergo a 3-hour fast from food and a 12-hour fast from caffeine and alcohol before their visit and to refrain from exercise the day of their visit (Bitar et al., 2015).

1.2 Experimental Design

A prone position was utilized as lower limb measurements were accessed using the popliteal artery. Previous work has shown that lower limb blood flow is maintained by VSR excitation during head-down flexion via increased popliteal vascular conductance and popliteal vasoconstriction (Ray, 2000; Villar & Hughson, 2013). Access to the popliteal artery was achieved by having participants in the prone position with their heads supported by a massage table head cushion (Fig. 2). In the baseline position, the neck was extended to approximate gravitational input at the vestibular otoliths when the participant is in an upright posture (Ray, 2000). Three electrocardiogram (ECG) electrodes were placed, one on the upper left trapezius and two on the bottommost rib on either side of the ribcage. A standard blood pressure cuff was placed over the left brachial artery. To control for the respiratory influence on heart rate, a metronome was employed to pace participant breathing at twelve breaths per minute (i.e., 0.25 Hz; Yates, 2014). Lastly, participants wore a blindfold during all measures to control for the oculocardiac reflex (Yates, 2014).

After three minutes of consistently paced breathing, baseline measures were collected in the supported prone position. With assistance from an investigator, the participant lifted their head, the face cushion was removed, and the participant lowered their head over the edge of the exam table until maximal flexion was reached (head down flexion). Once the participant was settled, paced breathing was established, and experimental measurements were collected. All measurements were obtained in a quiet and naturally lit room.

2.3 Measurements

Before baseline or head-down flexion measurements were obtained, the degree of head extension (baseline) and flexion (experimental) was measured using a standard goniometer by placing the stationary arm perpendicular to the floor and aligning the free arm to the base of the nose (Surkari et al., 2021). Change of head angle (ΔHeadAng) was calculated by subtracting neck extension from neck flexion and used to investigate possible thresholds regarding changes in gravitational vectors and the vestibulo-sympathetic reflex.

Systolic and diastolic blood pressures were measured using a standard blood pressure cuff placed over the brachial artery of the left arm. Brachial pressures were used to calculate each participant's mean arterial pressure (MAP) as follows:

$$MAP = (1/3SBP) * (2/3DBP)$$ (Parker et al., 2006)

Applanation tonometry is an accurate, non-invasive representation of the aortic pressure waveform (Nelson et al., 2010). Augmentation index (AIx), an indirect measurement of arterial stiffness (i.e., cardiovascular health), was assessed using applanation tonometry by placing a high-fidelity strain gauge transducer over the right radial artery (SphygmoCor; AtCor Medical; Sydney, Australia) (Nelson et al., 2010). The SphygmoCor system uses an FDA-approved transfer function to approximate central pressure waveforms, a protocol validated against non-invasive and intra-arterially measured pressure waves (Gallagher, Adji, & O'Rourke, 2004). Measured radial pressure waveforms were used to synthesize central pressure waveforms via the SphygmoCor system. Radial pressures were chosen as our participants were prone; thus, the carotid and femoral measurement sites were inaccessible. Radial waveforms were calibrated using estimated aortic distance and diastolic and mean arterial pressures. Aortic distances were calculated by measuring from the carotid artery to the sternal notch and from the sternal notch to the femoral artery and summing the lengths; arteries were located by palpation. The augmentation index was defined as the ratio between augmentation pressure and pulse pressure, or $AI = [(Ps – Pi)/(Ps-Pd)]*100$, where Ps is the peak systolic pressure, Pi is the infliction point where the reflected pressure wave causes an upstroke, and Pd is the peak end-diastolic pressure. Baseline and experimental measures of blood pressure and augmentation index were assessed in duplicate and averaged for each participant.

All popliteal measurements were collected via ultrasound by a 7.5-10.0 MHz linear-array probe (ProSound α7, Aloka; Tokyo, Japan). Popliteal blood flow velocity (PBV) and popliteal artery diameter (AD) were obtained in B-mode. PBV was assessed using the mean velocity provided by the ultrasound system. Artery diameter was selected from a single still image taken during peak systole as identified by the R-wave via three-lead ECG. ECG measurements were continuously taken during baseline and head-down flexion, and heart rate was assessed using a three-lead ECG. Popliteal blood flow velocity and artery diameter were measured at the same site and by the same operator for all measures. Popliteal peak blood flow (PBF) was estimated using PBV and AD and was calculated from the formula:

$$PBF\ (ml\ min - 1)\ =\ PBV * \pi r^2 * 60$$

where *r* is the artery's radius (Parket et al., 2006). Popliteal vascular conductance (PVC) was estimated as PBF/MAP (Parker et al., 2006).

Vitamin D analysis was conducted using a validated Food Frequency Questionnaire (FFQ). The FFQ was previously validated against biomarker analysis in 50 students and staff (14 males and 26 females; 35±12 years) at the University of Chester, Northern England, United Kingdom (Watkins, Freeborn, & Waushtaq, 2020; Appendix – Vitamin D FFQ). Following the format of the validation study, participants in this study were instructed to indicate the consumption frequency of each food item that best reflected their typical diet. Consumption of foods was measured using the following frequencies: never/less than monthly, monthly, 1/week, 2/week, 3/week, 4–5/week, daily or 2/d. Frequencies were normalized by converting all frequencies to a daily scale by dividing the reported frequency by 365. Vitamin D intake (Vit D) was then calculated by multiplying consumption frequency by the amount of vitamin D in the specified portion size of each food and reported in micrograms (mcg) (Appendix – Vitamin D Intake Key).

The Orthostatic Hypotension Questionnaire (OHQ) was used to assess our participants' prevalence of orthostatic hypotension (Kaufmann et al., 2012). The OHQ was developed and validated to accurately evaluate the severity of symptoms and the functional impact of orthostatic hypotension. It comprises two sections: the six-item symptom assessment scale and the four-item daily activity burden scale. Both areas were scored on a Likert scale (0-10), where high scores signify decreased orthostatic tolerance, then summed to produce an overall orthostatic tolerance score (OTS, Appendix – Orthostatic Hypotension Questionnaire)**.**

2.4 Statistical Analysis

Statistical analysis was performed using IBM SPSS Statistics 28 software (IBM, Armonk, NY). An independent t-test was conducted to assess age, BMI, change in head angle, OTS, and vitamin D scores between genders; as a result, age, sex, and change in head angle were used as covariates for all analyses. One-way variance analysis with repeated measures was performed to examine baseline and head-down flexion differences. Pearson correlations were determined between vitamin D intake and cardiovascular measurements. Statistical significance was defined as an α-level of 0.05. Data are presented as means ± standard deviation (SD).

2. Results

3.1 Participant Characteristics

Subject characteristics and independent samples t-test results are presented in Table 1. A total of 31 healthy adults (17 male and 14 female) participated in the study. There were no statistical differences in BMI, OTS, or vitamin D scores. There was a significant difference in age between males (*M* = 25.41, *SD* = 5.65) and females (*M* = 21.50, SD = 3.53; *t* (27.2) = 2.35, *p*=0.01 (one-tailed)). Male participants were significantly older than female participants, and the magnitude of the difference (mean difference = 3.91, 95% CI: 0.35 to 7.47) was large (eta square = 0.16). There was also a significant difference in the change of head angle between males (*M* = 101.24, *SD* = 10.15) and females (*M* = 89.07, *SD* = 12.33); *t* (29) = 3.02, p=0.003 (one-tailed). Females exhibited less change in head angle than males. Once again, the magnitude of differences in the means (mean difference = 12.16, 95% CI: 3.91 to 20.42) was large (eta square = 0.24).

3.2 Cardiovascular Responses to Head-Down Flexion

Cardiovascular data are presented in Table 2. There was a small yet significant decrease in brachial systolic blood pressure (2.26 ± 1.46 mmHg, P < 0.05); however, brachial diastolic blood pressure remained unchanged. The slight drop in systolic pressure may have contributed to the small, significant decrease in MAP (1.06 ± 1.49 mmHg, P < 0.05). Similarly, there was a slight, yet significant, decrease in heart rate (0.59 ± .10 bpm, P < 0.05). Compared to baseline, the augmentation index fell threefold during HDF (P < 0.05). Further, head-down flexion reduced popliteal blood velocity by 1.13 ± 0.54 cm/s (P < 0.05). Similarly, popliteal blood flow decreased by 10.0 ± 5.2 ml/min (P < 0.05) during head-down flexion. However, popliteal vascular conductance and popliteal artery diameter remained unchanged across positions.

3.3 Vitamin D and the Cardiovascular Response to HDF

The relationships between vitamin D intake, measured by the FFQ, and the cardiovascular responses to head-down flexion were investigated using Pearson correlations (Table 3). Data for the tendency toward orthostatic hypotension, as measured by the OHQ, are presented in

Table 1. Mean vitamin D consumption was 3.36 ± 2.39 mcg/day. No significant relationships were found between vitamin D intake and cardiovascular response to head-down flexion. The mean orthostatic tolerance score was 6.18 ± 8.16.

4. Discussion

4.1 The Cardiovascular Responses to Head-Down Flexion

Cardiovascular responses regarding HDF's effect on blood flow regulation are well documented. It is generally agreed that SBP drops during head-down flexion, followed by an increase in heart rate and vasoconstriction, via the vestibulo-sympathetic reflex aimed at safeguarding cardiac output (Lee et al., 2001; Ray, 2000; Yates, Bolton, & Macefield, 2014). Our findings of decreased systolic and mean arterial pressures during HDF are consistent with previous head-down flexion findings (Naylor et al., 2005; Carter & Ray, 2008; Lee et al., 2001); however, we did not detect a significant change in heart rate during head-down flexion, contrasting previous work (Lee et al., 2001).

As HDF increases sympathetic nerve activity accompanied by a parasympathetic withdrawal, it is reasonable to suggest that blood pressure control during HDF is largely maintained via vasoconstriction, especially in the lower limbs. However, this study found that SBP and MAP significantly decreased during HDF, albeit minimally. The cardiovascular findings of this study suggest that the previously reported increases in sympathetic outflow during HDF are regionally specific and not a general systemic response.

Further, our drop in blood pressure during HDF may result from decreased vessel stiffness. During HDF, AIx, a measure sensitive to vascular stiffness, decreased threefold, suggesting an increase in endothelial function. Due to the positive relationship between arterial stiffness and cerebral blood pressure during orthostasis (Tucker, 2022), it is reasonable to suggest that the dramatic drop in AIx aids in maintaining cerebral blood flow during inverted body positions. For instance, when inverted between -10° and -30°, dynamic fluid shifts cause a rapid decrease in lower limb blood volume followed by rapid increases in upper body blood volume, yet cerebral blood pressure remains unchanged (Cooke, Pellegrini, & Kovalenko, 2003; Kato et al., 2022). The mechanism regarding this phenomenon is unclear, and no data have been published regarding AIx and cerebral blood pressures during HDF. Our findings suggest that the vestibulo-sympathetic reflex may aid in safeguarding cerebral vasculature from increased shear stress during changes in body positions, especially during inversion. However, further research regarding arterial stiffness and cerebral blood flow before, during, and after HDF is needed.

The cardiovascular responses of the lower body resulting from a change in head position were relatively minor in contrast to the dramatic reaction of the upper body. The stress promoted from the baseline position to HDF resulted in a significant drop in popliteal blood velocity and popliteal blood flow, aligning with previous findings (Villar & Hughson, 2012). Villar and Hughson also reported a ~82% increase in popliteal vascular compliance during VSR activation, contrasting our non-significant decrease in popliteal vascular compliance; however, their study utilized a tilt table protocol focused on fluid shift dynamics regarding body position. In contrast, the current study focused on the vestibular sympathetic reflex using the head-down flexion protocol, thereby controlling for systemic fluid shifts. Our lack of PVC response suggests that the VSR is not the primary force influencing lower limb vascular conductance during inverted body positions.

Further, previous research has suggested lower limb vasoconstriction during head-down flexion occurs due to a linear increase in lower limb muscular sympathetic nerve activity during HDF (Hume & Ray, 1999), yet we did not see a significant change in popliteal artery diameter. However, the linear increase in lower limb MSNA may depend on the magnitude (i.e., degrees) of head flexion achieved during HDF. The current study saw an average change in head angle from baseline to HDF of 95.7 ± 12.6°. In contrast, Hume & Ray (1999) reported an average change in head angle of 128 ± 5° though lower limb vasoconstriction was not measured. Therefore, it is reasonable to suggest an angle of inversion threshold for lower limb MSNA activation during HDF exists and that the angle of change in the present study was insufficient to elicit marked differences in lower limb vasoconstriction. Follow-up research is needed to investigate the relationships between changes in head angle, MSNA activation, and lower limb vasoconstriction during HDF.

4.2 Vitamin D Consumption and the Cardiovascular Response to HDF

Several studies have reported vitamin D's significance in maintaining cardiovascular and vestibular system health and performance (Norman and Powell, 2014; Dong et al., 2010; Sanyelbhaa & Sanyelbhaa, 2014; Wu et al., 2022). For instance, Mheid et al. (2011) reported vitamin D blood serum levels to be inversely associated with AIx and PWV, suggesting a decrease in arterial stiffness and an increase in endothelial function with increased vitamin D serum levels. Similarly, vitamin D deficiency, defined as <20 ng/mL of serum 1,25-dihydroxyvitamin D, has been shown to increase the risk of chronic hypertension, peripheral artery disease, and systemic arterial stiffness in the general population (Chen et al., 2016; de la Guia-Galipienso et al., 2021). Further, vitamin D serum levels are negatively associated with otolith organ function, postural balance, body control, and spatial awareness and are positively related to cranial nerve signal transduction (Minasyan et al., 2009). These findings suggest that adequate vitamin D consumption may increase cardiovascular health in the general population.

However, this study failed to elicit significant relationships between vitamin D consumption and the vestibulo-sympathetic responses during head-down flexion. The lack of response during this study may be linked to the very low vitamin D levels consumed within our sample. Dong et al. (2010) found that consuming 50 mcg of vitamin D per day via liquid supplementation for 16 weeks resulted in significantly higher vitamin D blood serum levels and significantly lower central PWVs compared to those consuming only 10 mcg per day. Further, the National Institute of Health recommends a daily intake of 15 mcg of vitamin D to maintain baseline physiology. However, the average vitamin D intake in the current study was 3.36±2.39 (mcg). Therefore, it is reasonable to suggest that our sample population may not consume enough vitamin D to affect cardiovascular or vestibular function during HDF. When investigating vitamin D's role in the vestibulo-sympathetic reflex during HDF, follow-up studies should consider utilizing blood serum levels and a treatment protocol to examine the effects of vitamin D supplementation on the VSR during head-down flexion.

4.3 Limitations

The lack of significant findings in the current study may result from our assessment of vitamin D consumption (i.e., status). Food frequency questionnaires are ideal as they are simple to administer, cost-effective, timesaving and require only one visit. However, FFQs are subject to recall bias and may be inaccurate regarding specific nutrient consumption portion sizes. Additionally, FFQs are often validated against specific demographics and thus may not represent more diverse dietary habits. Moreover, this study collected data during the late summer, although sun exposure was not controlled for within the FFQ and therefore was not included as a consumption source. Collectively, the limitations of our vitamin D assessment may have led to our sample appearing to consume inadequate amounts of vitamin D. Further, this study did not utilize a "vitamin D sufficient" group. Therefore, we could not contrast the cardiovascular response to HDF between sufficient and insufficient vitamin D consumption.

Another consideration is the influence of co-nutrients. For instance, calcium and phosphate are vital nutrients within the cardiovascular and vestibular systems, and their levels within the body are closely regulated by vitamin D status (Myung et al., 2021; McKeen, Rahman, and Parham, 2020). However, this study did not account for calcium or phosphate status, nutrients deleterious to the cardiovascular and vestibular systems when serum levels are imbalanced. Further, our sample's change in head angle may not have been sufficient to elicit significant vestibulo-sympathetic reflex signals; therefore, follow-up studies must ensure their sample reaches maximal extension at baseline and flexion during HDF. Lastly, the current study's relatively small sample size may have limited our ability to detect significant relationships between vitamin D consumption and the vestibulo-sympathetic reflex during HDF.

4.4 Summary

This study aimed to identify novel relationships between vitamin D consumption and the vestibulo-sympathetic reflex during head-down flexion. Consistent with previous work regarding the vestibulo-sympathetic reflex, upper and lower body responses were observed, including decreases in blood pressure and lower limb blood flow and blood flow velocity. The most prominent finding was that head-down flexion induced a three-fold decline in the augmentation index, suggesting that the vestibulo-sympathetic reflex may protect the cerebral vasculature from increased shear stress during changes in body positions, especially during inversion. However, the current study failed to detect significant relationships between vitamin D consumption and the upper and lower body responses to head-down flexion. Non-significance was likely due to insufficient vitamin D consumption throughout the study sample and insufficient changes in head angle. Future investigations should examine vitamin D status objectively (e.g., blood serum levels) and establish a minimum change in head angle to ensure excitation of the vestibulo-sympathetic reflex.

TABLES

Table 1 Selected Subject Characteristics

	Total	Male (n=17)	Female (n=14)	t	df	Mean Difference	Eta Square
Age, yrs	23.65±5.14	25.41±5.65	21.50±3.53†	2.35	27.2	3.91	0.16
BMI, kg/m^2	24.31±3.81	25.18±3.14	23.26±4.37	1.42	29	1.92	0.07
ΔHeadAng, degrees	95.74±12.60	101.24±10.15	89.07±12.33†	3.02	29	12.16	0.24
OTS	6.18±8.16	5.4±9.02	7.08±7.23	-0.54	26	-1.68	0.01
VitD Score, mcg	3.36±2.39	3.96±2.39	2.72±2.30	1.43	27	1.25	0.07

BMI, body mass index; ΔHeadAng, change in head angle; OTS, orthostatic tolerance score; VitD Score, vitamin D score. Values expressed as mean ± SD; † $P < 0.05$ vs. Male

Table 2 Cardiovascular Response to Head Down Flexion

	Baseline	Head Down Flexion
SBP, mmHg	111.23±10.39	108.97±8.93*
DBP, mmHg	69.03±6.88	68.58±5.73
MAP, mmHg	83.10±7.17	82.04±5.68*
HR, beats/min	63.77±12.30	63.18±12.20*
AIx, %	-3.76±11.29	-11.36±12.25*
AD, mm	4.95±0.58	4.86±0.64
PBV, cm/s	4.12±2.62	3.25±2.18*
PBF, ml/min	43.1±22.4	33.1±17.2*
PVC, ml·min/mmHg	0.52±0.26	0.40±0.20

SBP, systolic blood pressure; DBP, diastolic blood pressure; MAP, mean arterial pressure; HR, heart rate; AIx, augmentation index; AD, popliteal artery diameter; PBV popliteal blood velocity; PBF, popliteal blood flow; PVC, popliteal vasculature conductance. * $P < 0.05$ vs. Baseline

Table 3 Pearson Correlations Between Vitamin D and the Cardiovascular Response to Head Down Flexion

		Vitamin D Score
SBP, mmHg	Baseline	0.01
	HDF	0.06
DBP, mmHg	Baseline	0.12
	HDF	0.08
MAP, mmHg	Baseline	0.08
	HDF	0.08
HR, beats min^{-1}	Baseline	0.12
	HDF	0.07
AIx, %	Baseline	-0.22
	HDF	-0.22
AD, mm	Baseline	0.11
	HDF	0.26
PBV, cm s-1	Baseline	0.05
	HDF	-0.01
PBF, ml min-1	Baseline	0.17
	HDF	0.16
PVC, ml min-1 mmHg-1	Baseline	0.19
	HDF	0.15

SBP, systolic blood pressure; DBP, diastolic blood pressure; MAP, mean arterial pressure; HR, heart rate; AIx, augmentation index; AD, popliteal artery diameter; PBV, popliteal blood velocity; PBF, popliteal blood flow; PVC, popliteal vasculature conductance.
*P < 0.05 vs. Baseline

FIGURES

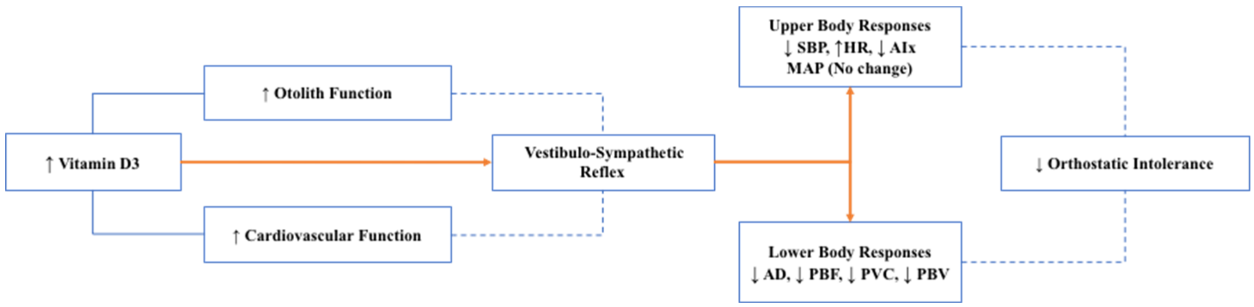

Figure 1 Concept Map.

Due to vitamin D's role in cardiovascular and otolith health, the vestibulo-sympathetic reflex may be vulnerable to vitamin D deficiencies though no data has been presented concerning this topic. The solid blue lines represent established relationships between vitamin D and otolith and cardiovascular function. The dotted blue lines represent theoretical relationships based on current literature. Lastly, the solid orange lines represent the design of this pilot study and the hypothesized relationships between vitamin D and the upper and lower body responses to head down flexion.

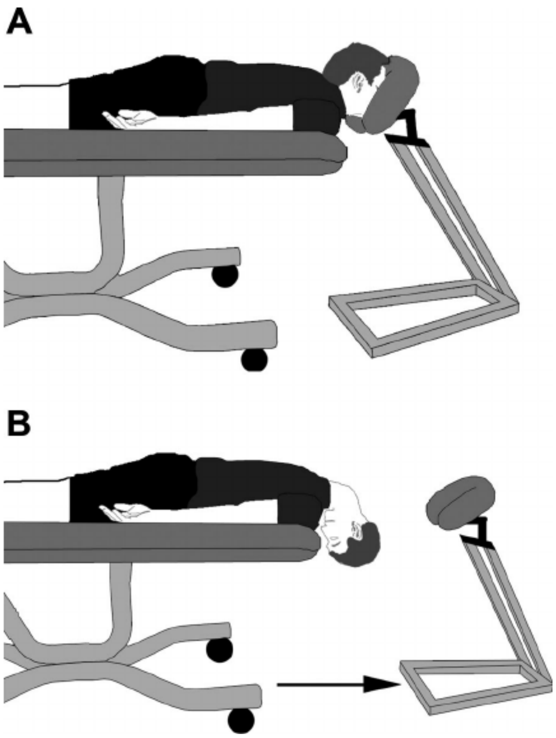

Figure 2 Illustration of head down flexion (HDF).

A: In the baseline position, the subject's head is supported, and the neck extends. B: HDF, the head support is removed, and the head is allowed to hang freely off the end of the table. This procedure was first detailed by Short & Ray (1997).

APPENDICES

Orthostatic Hypotension Questionnaire (OHQ)

As you go from lying down or sitting to standing, do you experience any of the following symptoms? Please tick the number on the scale that best rates your answers over the past week. You should respond to every question. If you do not experience a symptom, circle zero (0).

1. Dizziness, lightheadedness, feeling faint, or feeling like you might black out None

0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10 ☐ Worst possible

2. Problems with vision (blurring, seeing spots, tunnel vision, etc.)

None 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10 ☐ Worst possible

3. Weakness

None 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10 ☐ Worst possible

4. Fatigue

None 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10 ☐ Worst possible

5. Trouble concentrating

None 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10 ☐ Worst possible

6. Head and neck discomfort

None 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10 ☐ Worst possible

During the past week, have any of the symptoms you reported above interfere with any of your daily activities?

1. Activities that require standing for a short time ☐ Cannot do for other reasons
No interference 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10 ☐ Total interference

2. Activities that require standing for a long time ☐ Cannot do for other reasons
No interference 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10 ☐ Total interference

3. Activities that require walking for a short time ☐ Cannot do for other reasons
No interference 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10 ☐ Total interference

4. Activities that require walking for a long time ☐ Cannot do for other reasons
No interference 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10 ☐ Total interference

Food Frequency Questionnaire for Vitamin D Intake

Please complete the FFQ by ticking the relevant box for the correct frequency that you consume the food item listed. Portion size is listed either within the heading or in the column next to the food item.
Do not report any foods that are not itemized in the questionnaire.

FOODS AND AMOUNTS	PORTION SIZE	FREQUENCY OF CONSUMPTION							
		Never/less than monthly	Monthly	1 per week	2 per week	3 per week	4-5 per week	Daily	2 per day
PASTA									
Egg noodles	Medium								
BREAKFAST CEREALS									
Bran type cereal, fortified	One medium bowl								
Bran flakes, fortified	One medium bowl								
Cornflakes, fortified	One medium bowl								
Cornflakes frosted, fortified	One medium bowl								
Honey loops and hoops, fortified	One medium bowl								
Malted flake cereal, fortified	One medium bowl								
Malted wheat cereal, fortified	One medium bowl								

FOODS AND AMOUNTS	PORTION SIZE	FREQUENCY OF CONSUMPTION							
		Never/less than monthly	**Monthly**	**1 per week**	**2 per week**	**3 per week**	**4-5 per week**	**Daily**	**2 per day**
Oat cereal, instant, plain, fortified	One medium bowl								
Rice cereal, toasted crisp, fortified	One medium bowl								
Rice cereal chocolate flavour, fortified	One medium bowl								
MILK AND CREAM									
Cream	Average serving								
Evaporated milk	Tablespoon								
EGG AND EGG DISHES									
Whole egg	One egg								
Omelette	One egg								
Quiche	Medium slice								
CHEESE									
Brie	Medium portion								

FOODS AND AMOUNTS	PORTION SIZE	FREQUENCY OF CONSUMPTION							
		Never/less than monthly	Monthly	1 per week	2 per week	3 per week	4-5 per week	Daily	2 per day
Camembert	Medium portion								
Cheddar	Medium portion								
Cheddar type 30% fat	Medium portion								
Cheese spread	Medium portion								
Danish blue	Medium portion								
Double Gloucester	Medium portion								
Edam	Medium portion								
Feta	Medium portion								
Goats cheese	Medium portion								
Gouda or Halloumi	Medium portion								
Mascarpone	Medium portion								
Mozzarella	Medium portion								
Parmesan	Medium portion								

FOODS AND AMOUNTS	PORTION SIZE	FREQUENCY OF CONSUMPTION							
		Never/less than monthly	Monthly	1 per week	2 per week	3 per week	4-5 per week	Daily	2 per day
Processed cheese	Medium portion								
Red Leicester	Medium portion								
Spreadable cheese	Medium portion								
Stilton blue	Medium portion								
Wensleydale	Medium portion								
YOGHURTS									
Greek yoghurt	One pot								
Low fat yoghurt	One pot								
Soya yoghurt	One pot								
MEAT AND MEAT PRODUCTS									
Bacon	As part of a meal								
Beef and Veal	As part of a meal								
Lamb	As part of a meal								

FOODS AND AMOUNTS	PORTION SIZE	FREQUENCY OF CONSUMPTION							
		Never/less than monthly	Monthly	1 per week	2 per week	3 per week	4-5 per week	Daily	2 per day
Pork	As part of a meal								
Chicken	As part of a meal								
Turkey	As part of a meal								
Liver	As part of a meal								
Home cooked burger	As part of a meal								
Takeaway burger	As part of a meal								
Black pudding	As part of a meal								
Pâté	As part of a meal								
DESSERTS AND SWEET ITEMS									
Ice cream	Medium scoop								
Shortbread	One piece								
Cake bars	One								
Chocolate cake	One slice								

FOODS AND AMOUNTS	PORTION SIZE	FREQUENCY OF CONSUMPTION							
		Never/less than monthly	Monthly	1 per week	2 per week	3 per week	4-5 per week	Daily	2 per day
Fruitcake, homemade	One slice								
Sponge cake	One slice								
Eccles cake	One								
Éclairs, chocolate, cream filled	Medium portion								
Scotch pancakes	Medium portion								
Crumble	Medium portion								
Fudge, homemade	Size of snack bar								
FISH									
Herring	As part of a meal								
Kippers	As part of a meal								
Mackerel	As part of a meal								
Salmon	As part of a meal								
Wild salmon	As part of a meal								

FOODS AND AMOUNTS	PORTION SIZE	FREQUENCY OF CONSUMPTION							
		Never/less than monthly	Monthly	1 per week	2 per week	3 per week	4-5 per week	Daily	2 per day
Canned salmon, pink	As part of a meal								
Canned salmon, red	As part of a meal								
Fresh sardines	As part of a meal								
Canned sardines	As part of a meal								
Trout, baked	As part of a meal								
Tuna, baked	As part of a meal								
Tuna, canned	As part of a meal								
Molluscs	As part of a meal								
DRINKS									
Horlicks powder	One serving								
SAUCES									
Cream based dressings eg thousand island/blue cheese	For one salad								

FOODS AND AMOUNTS	PORTION SIZE	FREQUENCY OF CONSUMPTION							
		Never/less than monthly	Monthly	1 per week	2 per week	3 per week	4-5 per week	Daily	2 per day
Tartare sauce	For one meal								
Pesto, green	For one meal								

FOODS AND AMOUNTS		Mugs per week	Glasses per week	On cereal per week	Within tea/coffee per week
MILK AND CREAM					
Soya, non-dairy alternative to milk, sweetened,					
Soya milk, unsweetened, fortified					
Dried skimmed milk					
BUTTER AND SPREADS	**Please state number of servings per week - equivalent to amount for spreading on slice of bread**				
Butter spread					
Fat spread, reduced fat					
Fat spread, low fat					
Margarine					
VITAMINS AND SUPPLEMENTS	**Full name** e.g. Multibionta 50+ multivitamins; Seven Seas Cod Liver Oil; Asda Folic Acid		**Dose** e.g. 1000mg; 10µg; 400IU	**Amount taken** e.g. 1 capsule, 1 teaspoon (5ml)	**How Often** eg. once a day, three times a day
Supplement 1					
Supplement 2					
Supplement 3					

Food Frequency Questionnaire for Vitamin D Intake – Key for users

Food	Portion size (g) [1]	Vitamin D per portion (µg) [2]
Grains, pasta etc		
Egg noodles	280	0.28
Breakfast Cereals		
Bran type cereal, fortified	40	1.56
Bran flakes, fortified	40	1.84
Cornflakes, fortified	30	1.41
Cornflakes frosted, fortified	30	1.41
Honey loops and hoops, fortified	30	1.26
Malted flake cereal, fortified	40	3.32
Malted wheat cereal, fortified	40	1.16
Oat cereal, instant, plain, fortified	180	1.26
Rice cereal, toasted crisp, fortified	30	1.38
Rice cereal chocolate flavour, fortified	30	1.38
Milk and cream		
Cream	30	0.09
Evaporated milk	15	0.41
Egg and egg dishes		
Whole egg	57	1.8
Omelette	60	2.22
Quiche	140	1.26
Cheese		
Brie	30	0.06
Camembert	40	0.04
Cheddar	20	0.06
Cheddar type 30% fat	20	0.02
Cheese spread	30	0.03

Danish blue	30	0.06
Double Gloucester	20	0.06
Edam	40	0.08
Feta	30	0.15
Goats cheese	30	0.15
Gouda or Halloumi	40	0.08
Mascarpone	51	0.15
Mozzarella	40	0.08
Parmesan	15	0.05
Processed cheese	20	0.04
Red Leicester	20	0.06
Spreadable cheese	30	0.03
Stilton Blue	35	0.07
Wensleydale	25	0.05
Yoghurt		
Greek yoghurt	125	0.125
Low fat yoghurt	125	0.125
Soya yoghurt	125	1
Meat and meat products		
Bacon	46	0.28
Beef and veal	144	0.86
Lamb	90	0.54
Pork	90	0.63
Chicken	100	0.3
Turkey	90	0.36
Liver	100	0.5
Home cooked burger	90	1.08
Takeaway burger	106	0.32
Black pudding	75	0.53

Pâté	80	0.96
Desserts and sweet items		
Ice cream	75	0.38
Shortbread	13	0.05
Cake bars	30	0.39
Chocolate cake	65	0.26
Fruitcake, homemade	70	0.35
Sponge cake	60	0.72
Eccles cake	45	0.36
Éclairs, chocolate, cream filled	90	0.27
Scotch pancakes	110	0.66
Crumble	170	0.4
Fudge, homemade	11	0.1
Fish		
Herring	119	19.2
Kippers	130	13.1
Mackerel	160	13.1
Salmon	100	9.3
Wild salmon	100	10.3
Canned salmon, pink	100	13.6
Canned salmon, red	100	10.9
Fresh sardines	86	3.1
Canned sardines	100	3.6
Trout, baked	155	12.7
Tuna, baked	92	2.9
Tuna, canned	100	1.1
Molluscs	40	0.4
Drinks		
Horlicks powder	20	0.42

Sauces								
Cream based dressings eg thousand island/blue cheese	30				0.03			
Tartar sauce	30				0.06			
Pesto, green	26				0.18			
Milk and Cream	On cereal	Tea/coffee	Mug	Glass	On cereal	Tea/coffee	Mug	Glass
Soya, non-dairy alternative to milk, sweetened, fortified	100	35	230	200	0.8	0.28	1.84	1.6
Soya milk, unsweetened, fortified	100	35	230	200	0.8	0.28	1.84	1.6
Dried skimmed milk	100	35	230	200	1.5	0.53	3.45	3
Butter/spreads	Average spread on one slice							
Butter	10				0.09			
Butter spread	7				0.04			
Fat spread, reduced fat	10				0.42			
Fat spread, low fat	10				0.45			
Margarine	7				0.62			
Vitamins and supplements								
Supplement 1								
Supplement 2								
Supplement 3								

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CURRICULUM VITA

JUSTIN PASCUAL

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PROFESSIONAL SUMMARY

United States Air Force Technical Sergeant with 13 years of military experience and current graduate student with 5 years of academic and research expertise in human anatomy and physiology. Eager to advance the sciences of nutrition and exercise physiology by applying cutting-edge research practices to understand the connection between nutrient metabolism and stress-induced physiological adaptations to increase the functionality and longevity of humans worldwide.

CIVILIAN EDUCATION

M.S., Nutrition Science

Syracuse University, David B. Falk College of Sport and Human Dynamics, Syracuse, NY — Current

- Cumulative GPA: 3.92

B.S., Nutrition Science

Syracuse University, David B. Falk College of Sport and Human Dynamics, Syracuse, NY — 5/2020

- Cumulative GPA: 3.61
- Graduated Magna Cum Laude

A.A., General Studies

University of Maryland, University College, College Park, MD — 5/2015

- Cumulative GPA: 3.71

MILITARY EDUCATION

Non-Commissioned Officer Academy, Hancock Field, NY — 2020

Air Force Combat Ammunition Center, Beale Air Force Base, CA — 2014

Munitions Inspector School, Kunsan Air Base, Republic of Korea — 2013

Airman Leadership School, Kunsan Air Base, Republic of Korea — 2012

Munitions System Specials Technical School, Sheppard Air Force Base, TX — 2009

- Designated Graduate; awarded to 2nd highest in graduation class

TEACHING EXPERIENCE

Graduate Teaching Assistant, Syracuse University — 08/2020-Current

- Courses responsible for: Nutritional Biochemistry *(NSD456),* Advanced Nutrition *(NSD466),* Medical Nutrition Therapy *(NSD481),* Weight Management Obesity & Disordered Eating *(NSD625)*
- Delivered lectures in face-to-face and online formats (e.g., Zoom, Microsoft Teams, and Blackboard)
- Contributed to the development of lecture and study materials, homework assignments, and exams to ensure content and methods of delivery met learning objectives
- Held weekly office hours and recitation sessions to assist students in understanding course material, exam preparation, and transferring knowledge
- Responsible for grading exams and homework assignments
- Held peer advising/mentoring sessions

Kitchen Teaching Assistant, Syracuse University, Syracuse, NY — 2018-2020

- Assisted chefs with planning and organizing for physical lab sections of up to 36 students

- Prepared recipes and daily ingredients before class start time for all students, following recipes and requisition orders
- Taught students basic-to-advanced culinary techniques, equipment usage, product knowledge, and safety and sanitary practices

Summer Teaching Assistant, Syracuse University 06/2018-07/2018

- Responsible for the creation and teaching of labs, lectures, and homework assignments the Summer College Pre-Med & Health Professions program involving 45 high school students from around the world

Unit Physical Training Leader, 352nd Special Operations, RAF Mildenhall, U.K. 05/2013-02/2016

- Directly supervised/responsible for ensuring 100 percent combat readiness of 50 personnel
- Rebuilt and lead unit combat fitness program for 50 Airmen
- Created fitness and nutrition program for the Airmen, ensured all personnel stayed combat-ready, coaching a total of 250 hours of group fitness sessions
- Trained Non-Commissioned Officers in techniques and skills on how to mentor their team members regarding physical and mental preparedness

Honor Guard Lead Trainer, 509th Bomb Wing, Whiteman Air Force Base, MO 01/2011-01/2012

- Designed/led training program for base Honor Guard Team, the curriculum included detailed procedures for military funerals, color guard, base support ceremonies, and community functions
- Trained 40 Honor Guard Team Members across approximately 300-hours of instruction

PROFESSIONAL EXPERIENCE

Non-Commissioned Officer in Charge, Munitions Flight, Technical Sergeant, Hancock Field, N.Y. 06/2018-Current

- Status: Part-time; Drill Status Guardsmen
- Annual Salary: $12,000
- Work Schedule: Duty hours 0730-1600 one weekend a month with two to three weeks of Annual Training per year
- Mentors and leads a section of 8 Airmen responsible for inspecting, maintaining, building, and transporting munition assets in support of all 174th Attack Wing's training and contingency taskings
- Munitions Inspector, responsible for the completion of scheduled munition inspections and conducts certification training for fellow Munitions Inspectors, ensuring 100-percent section readiness

Diet Therapist, Technical Sergeant, Niagara Falls Air Reserve Station, N.Y. 02/2016-06/2018

- Status: Part-time; Drill Status Reservists
- Annual Salary: $12,000
- Work Schedule: Duty hours 0730-1600 one weekend a month with two to three weeks of Annual Training per year
- Developed and delivered material promoting health and community nutrition across the wing
- Provide day-to-day support to the Wing Fitness Manager by tracking, monitoring, and administering physical fitness assessments

Non-Commissioned Officer in Charge, Munitions Production, Staff Sergeant, RAF Mildenhall, U.K. 05/2013-02/2016

- Status: Full-time; Active Duty Servicemember
- Annual Salary: $42,000
- Work Schedule: Duty hours 0600-1500 Monday thru Friday
- Led a flight of 15 Airmen responsible for the security, accountability, and maintenance of a $1.8 million stockpile and the direct combat support for two special operations squadrons, one special

tactics squadron, and all transient Air Force Special Operations Command units within the U.S. European Command's area of responsibility
- Ensured Airmen proficiency with the maintenance, storage, transport, and security of various chaff and flare, small arms, and tactical ordnance systems
- Responsible for the enforcement of United States Air Force Europe and United Kingdom Ministry of Defense explosive safety regulations

Precision Guided Munitions Bay Chief, Senior Airman, Kunsan Air Base, Republic of Korea
05/2012-05/2013
- Status: Full-time; Active Duty Servicemember
- Annual Salary: $35,000
- Work Schedule: Duty hours 2300-0700 Monday thru Friday
- Responsible for the maintenance, inspection, building, and testing of 1.6-thousand Precision Guided munitions, including AIM-series and AGM-series assets
- Managed and briefed the status of the wing’s air-to-air and air-to-ground munitions stockpile worth $533 million
- Responsible for the safety, training, and career progression of 5 Airmen

Munitions Controller, Senior Airman, Whiteman Air Force Base, M.O. 12/2010-05/2012
- Status: Full-time; Active Duty Servicemember
- Annual Salary: $33,500
- Work Schedule: Duty hours 2300-0700 Monday thru Friday
- Coordinated daily munitions operations between flight line, flight operations, base support agencies, and 509th Munitions Squadron flight and element personnel, ensuring the safety, security, and accountability of nineteen sections, two-hundred and fifty-two personnel, seventy-eight vehicles, one-hundred and eighteen conventional and nuclear munitions trailers, and fifty-two B-2 bomber specific munitions launchers
- Validated and processed ordnance expenditures with flight-line expediter, thereby maintaining the integrity of the wing’s $272 million munition stockpile
- Responsible for the squadron’s successful execution of Emergency Action Checklists

Munitions Storage Crew Member, Airman First Class, Whiteman Air Force Base, M.O.
10/2008-12/2010
- Status: Full-time; Active Duty Servicemember
- Annual Salary: $29,000
- Work Schedule: Duty hours 0730-1630 Monday thru Friday
- Maintained, transported, and secured munitions assets valued at $272 million in support of all 509th Bomb Wing training and contingency taskings
- Responsible for maintaining 23 munitions storage structures and all munitions support equipment

RESEARCH EXPERIENCE

Master’s Thesis, Syracuse University, Syracuse, NY 08/2020-Current
- Title: “Vitamin D_3 Status and the Cardiovascular Response to Head Down Flexion in Healthy Adults”
- Advisors: Dr. Margaret Voss, Dr. Kevin Heffernan, Dr. Lynn Brann
- Objective: To elucidate relationships linking vitamin D consumption and the vestibulo-sympathetic reflex (VSR) by exploring the associations between self-reported vitamin D consumption and the cardiovascular responses to head-down flexion (HDF), a maneuver known to activate the vestibulo-sympathetic response.

Summer Graduate Research Assistantship, Syracuse University, Syracuse, NY 06/2020-08/2020
- Primary Investigator: Dr. Jessica Garay

- Conducted initial literature review focused on the differences in bioavailability between DHA, EPA, and ALA in the body and overall anti-inflammatory effects of vegetarian diets and any variations within different types of vegetarian diets
- The project is still in progress, data not available for publishing/presentation

Senior Research Project, Syracuse University, Syracuse, NY 08/2019-05/2020

- Title: "Endocrine Disruptors & Athletic Performance: BPA's Impact on Runner Osteogenesis"
- Research Advisor: Dr. Margaret Voss
- Researched the associations between environmental and dietary-derived bisphenol-A (BPA) and bone mineral density in males aged 25-45. The study was a secondary data analysis of data obtained from the National Health and Nutrition Examination Survey and focused on quantifying BPA intake from foods by cross-referencing 3-day dietary records and biochemical assays.
- Results presented at the 2020 McNair Scholars Symposium

McNair Scholars Research Academy, Syracuse University, Syracuse, NY 06/2018-05/2019

- Review Title: "Spaceflight Nutrition: Vitamin D's Role as an Immunoregulator in Microgravity Environments"
- My quantitative review paper focused on the relationship between vitamin D absorption in microgravity environments and its impact on the human immune system during spaceflight. The overall purpose of this research was to identify methods to prevent immune depression by way of maintaining immunological homeostasis via vitamin D consumption for astronauts and cosmonauts during spaceflight exploration
- Results presented at the 2019 McNair Scholars Symposium

PROFESSIONAL ACTIVITIES

Student Research Panel-Graduate Representative, Syracuse University 05/2021
Nutrition Science Research Panel, Falk College, Syracuse University 09/2020
Undergraduate Research Panel, Arts and Sciences, Syracuse University 11/2019
Student Highlight: "A Nutrition Student's Experience", Syracuse University 10/2018

PROFESSIONAL ORGANIZATIONS & SOCIETIES

American College of Sports Medicine 1/2021-Current
Student Researcher, Academy of Nutrition & Dietetics 3/2017-Current
Sports, Cardiovascular & Wellness (SCAN) Practice Group, Academy of Nutrition and Dietetics 3/2017-Current
McNair Scholars, Syracuse University 6/2018-5/2020
Nutrition Research Dietetics Practice Group, Academy of Nutrition and Dietetics 12/2017-5/2020
Nutrition Education & Promotion Association (NEPA), Syracuse University 8/2017-5/2020
New York Academy of Nutrition and Dietetics State Affiliate 3/2017-5/2020

MILITARY AWARDS & ACHIEVEMENTS

Superior Performer, 174th Attack Wing, Hancock Field, NY 2020

- Awarded for outstanding performance during the 174th Attack Wing's Combined Unit Inspection, one of two from the unit to receive this honor

New York State Physical Fitness Award, 174th Attack Wing, Hancock Field, NY 2020, 2019

- Awarded for scoring a 98.8-percent on annual fitness assessment

Air Force Accommodation Medal, U.S. Air Force 2016
Air Force Achievement Medal, U.S. Air Force 2012; 2013; 2016
Non-Commissioned Officer of the Quarter, 352nd Special Operations Squadron, Mildenhall, U.K. 2016
Outstanding Performer, J3, Special Operations Command Europe 2014

- Awarded for outstanding performance as the Non-Commissioned Officer in Charge, Munitions

Flight, during the largest NATO exercise in 2014, Exercise Jackal Stone, Baumholder, Germany

Honor Guard Team Trainer of the Year, 509th Bomb Wing, Whiteman, MO 2012

- Awarded to the top trainer base on professionalism, precision, merit, quality of trainees taught, and peer-critiques

Airman of the Year, 509th Munitions Squadron, Whiteman Air Force Base, MO 2010

CIVILIAN AWARDS & ACHIEVEMENTS

Graduate Assistantship, Syracuse University 2020-2021, 2021-2022

Susan J Crockett Prize for Student Leadership, Syracuse University Spring 2020

SOURCE Grant Recipient, Syracuse University 2019-2020

Dean's List, Syracuse University Spring, 2017; Fall 2017; Spring 2018; Fall 2018; Fall 2019, Spring 2020

Dean's List, University of Maryland – University College Spring 2015

VOLUNTEER EXPERIENCE

David B. Falk College, Syracuse University 1/2018-5/2020

Student Ambassador

- Assisted the Admissions Office staff with important recruitment activities, including open houses, university tours, and provided student mentorship to prospective and incoming students

Academy of Nutrition and Dietetics, National 8/2017-5/2020

Student Liaison-Syracuse University

- Participate in recruitment and retention of student members and provide feedback on student initiatives

Back to the Classroom Program, Syracuse University 09/2019

Operator – Indirect Calorimetry

- Operated and taught the indirect calorimetry equipment during Orange Central; a benefactor and university alum focused event

West Side Physical Therapy, Syracuse, NY 3/2019-10/2019

PT Aide Volunteer

- Assisted with patient treatments as directed by the mentoring physical therapist, maintained treatment areas, equipment, supplies

Chittenango Physical Therapy, Chittenango, NY 5/2019-11/2019

PT Aide Volunteer

- Assisted with patient treatments as directed by the mentoring physical therapist, maintained treatment areas, equipment, supplies

Onondaga Physical Therapy, Syracuse, NY 3/2019-5/2019

PT Aide Volunteer

- Assisted with patient treatments as directed by the mentoring physical therapist, maintained treatment areas, equipment, supplies

Academy of Nutrition and Dietetics – House of Delegates 6/2018-6/2019

At-Large Student Delegate

- Entrusted to speak on behalf of all dietetic nutritionist students worldwide regarding challenges facing the profession
- Attended monthly video meetings to discuss current and evolving issues and solution; participated at the annual House of Delegates meeting in Washington, D.C., to lobby for policy change regarding student issues

Veteran Affairs Medical Center, Syracuse, NY 6/2017-8/2018

Student Volunteer – Physical Therapy

- Assisted with patient treatments as directed by the mentoring physical therapist, maintained treatment areas, equipment, supplies

Schine Center, Syracuse University 8/2017-12/2017

Books & Cooks Volunteer

- Provided tutoring and nutritional information to elementary school students to improve literacy rates and healthy habits
- Facilitated hands-on food preparation and nutrition lessons, introducing elementary students to a different culture each week