Examination of the Monoamine Oxidase A Gene Promoter on Motivation to Exercise and Levels of Voluntary Physical Activity

E. Kinney[1], S. Coste[1], C. Reinke[2]

[1]Department of Health, Human Performance & Athletics, [2]Department of Biology

Linfield College – McMinnville, OR

Abstract

PURPOSE: The purpose of this study is to examine the genetic basis underlying voluntary exercise. Monoamine oxidase A (MAO-A) is an enzyme that acts on monoamine neurotransmitters, such as dopamine, to cause inactivation. There are several polymorphisms in the promoter region of the MAO-A gene and these variations change transcriptional activity and the amount of MAO-A produced, leading to alterations in available dopamine levels. Interestingly, polymorphisms in MAO-A have been associated recently with physical activity level. This study sought to determine whether there is an association between motivation to exercise, levels of voluntary physical activity and monoamine oxidase A (MAO-A) gene polymorphisms. METHODS: Seventy-one participants (age 18-24 years, 13 males & 58 females) completed the Behavioral Regulation in Exercise Questionaire-2 (BREQ-2) to assess their motivation to exercise and the International Physical Activity Questionnaire (IPAQ) to assess their level of physical activity. DNA was collected and isolated from a cheek cell sample. The MAO-A genotype was identified using PCR with gene specific primers. MAO-A 3/3 and 4/4 genotype individuals were used for analysis. RESULTS: External motivation to exercise was significantly higher ($p < 0.01$) in the high transcription 4/4 genotype (ave 1.11 ± 0.8) compared to the low transcription 3/3 genotype (ave 0.39 ± 0.6). Internal motivation to exercise was not different between genotypes. Body mass index and weekly MET minutes estimated by IPAQ were also comparable between genotypes. CONCLUSION: The results suggest a polymorphism in this monoamine pathway may play a role in increasing sensitivity to external factors that motivate individuals to exercise.

Purpose

The purpose of this study was to examine whether physical activity levels and/or motivation to exercise is associated with a genetic polymorphism or variation in the promoter region of a gene that regulates transcription of monoamine oxidase A (MAO-A). This enzyme regulates dopamine levels in the brain and thus can alter dopaminergic transmission pathways of motivation.

Introduction

There are a number of factors that may explain low physical activity levels including, inadequate time, insufficient resources or negative affect toward exercise. Extrinsic motivators such as peer pressure can be used to initiate exercise programs, however, intrinsic motivators are needed to continue daily exercise protocols (Good, Li & Deater-Deckard, 2015). Intrinsic motivation is thought to involve dopamine transmission in the brain (Goldfield et al., 2013). Several studies have shown that genetic variations in components of brain dopaminergic pathways affect the amount of voluntary exercise in mouse models. However, few studies have examined human genetic variations in this pathway that may impact exercise levels and motivation to exercise. Monoamine oxidase A and B (MAO-A and MAO-B) are enzymes that act on monoamine neurotransmitters, such as dopamine, to cause inactivation of the neurotransmitter. There are several variations or polymorphisms in the promoter region of the MAO-A gene and these variations change transcriptional activity and the amount of MAO-A produced. The 3-repeat variable nucleotide tandem repeat (3/3 VNTR) polymorphism results in low transcription of MAO-A while the 4-repeat variable nucleotide tandem repeat (4/4 VNTR) has high transcriptional activity. The 4/4 VNTR polymorphism may lead to increased MAO-A activity and thus reduced dopamine available for signaling. Lower dopaminergic signaling may correlate with reduced motivation to exercise and/or overall levels of voluntary exercise.

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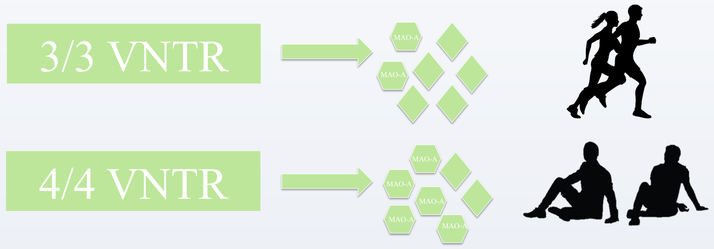

Figure 1. Low transcriptional 3/3 VNTR leads to low levels of MAO-A (hexagon shape) and a higher concentration of dopamine (diamond shape). The high transcriptional 4/4 VNTR leads to high levels of MAO-A and therefore lower concentration of dopamine.

Materials and Methods

Seventy-one participants were recruited from the Linfield student body (13 males & 58 females). Each participant completed the International Physical Activity Questionnaire (IPAQ) to determine their level of physical activity and the Behavioral Regulation in Exercise Questionaire-2 (BREQ-2) to assess their motivation to exercise. DNA was collected and isolated from a cheek cell sample. PCR and gene specific primers were used to identify the MAO-A genotype of each participant. Only MAO-A 3/3 and 4/4 genotype individuals were used for analysis. An one way ANOVA compared physical activity level, MET minutes per week, BREQ-2 score, internal motivation score and external motivation score between genotypes.

Results

Table 1. Demographics

	N	Minimum	Maximum	Mean	Standard Deviation
Age (years)	72	18	24	19.5	1.4
Height (m)	72	1.44	1.88	1.68	0.09
Weight (kg)	72	46.2	139.3	70.5	14.7
BMI (kg/m^2)	72	19.1	49.1	24.9	4.7

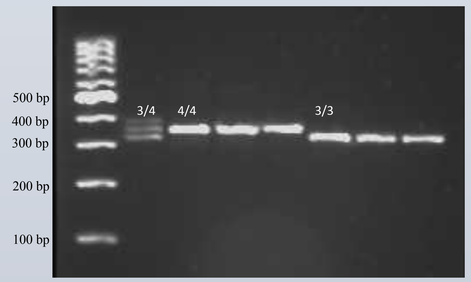

Figure 2. Gel showing a 3/4 VNTR genotype with three bands between 300 and 400 bp, a 3/3 VNTR genotype band at 324 bp, and a 4/4 VNTR genotype band at 354 bp

Table 2. Genotype Frequencies

Genotype	N
3/3 VNTR	16
4/4 VNTR	22
3/4 VNTR	27

Table 3. IPAQ physical activity category frequencies

	Mean MET minutes per week	IPAQ physical activity category		
		1(Low)	2 (Moderate)	3 (High)
3/3 VNTR	4017 ± 3564	1	7	7
4/4 VNTR	5666 ± 3272	1	4	16

Individuals with the 4/4 VNTR genotype have high external motivation to exercise scores compared to the 3/3 VNTR genotype, no difference between genotypes in internal motivation to exercise

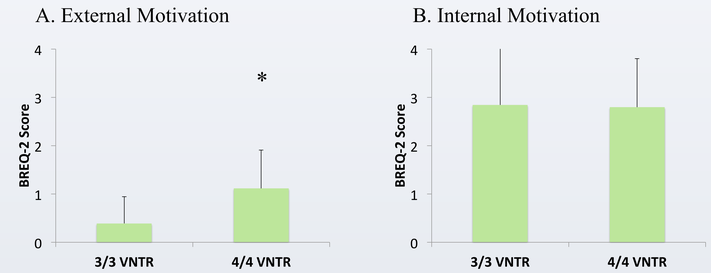

Figure 3A. External motivation to exercise scores were significantly higher in the high transcription 4/4 VNTR genotype compared to the low transcription 3/3 VNTR genotype. *p<0.01 **B.** Internal motivation to exercise scores were not significantly different between genotypes.

Summary and Conclusion

- Our results show that individuals with the high transcriptional 4/4 VNTR genotype report significantly higher scores in external motivation compared to the low transcriptional 3/3 VNTR genotype. Internal motivation scores were similar between the two genotypes. This suggests that the polymorphisms in the MAO-A gene promoter may increase sensitivity to external factors that motivate individuals to exercise.
- Physical activity levels and total MET minutes per week as assessed by IPAQ were similar between genotypes.
- Further research would be beneficial to investigate variations between males and females as well as investigate other genetic variations in the MAO-A pathway.

Limitations

- Our sample size was small with few males compared to females.
- Athletes who were in season were included. This is a limitation because these participants are required to exercise on a daily basis as a part of their sports practice, and cannot necessarily be considered voluntary exercise.
- Several participants (n=11) were excluded because they did not complete or fill out the surveys correctly.

Selected References

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**More references are available upon request.

Acknowledgments

We would like to thank the following individuals for making this research project possible:

Heather Long, Melanie Oord, Participants, & Linfield College Institutional Review Board

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