

Copyright is owned by the Author of the thesis. Permission is given for a copy to be downloaded by an individual for the purpose of research and private study only. The thesis may not be reproduced elsewhere without the permission of the Author.

Caffeine Consumption Habits, Motivations, and Experiences of New Zealand Tertiary Students

A thesis presented in partial fulfilment of the requirements for the degree of

Master of Science
In
Nutrition and Dietetics

at Massey University, Albany
New Zealand

Saskia Stachyshyn
2017

Abstract

Background: Caffeine-related health incidents in New Zealand have escalated over the last two decades. Research suggests that in order to reduce the risk of substance-related harm, it is important to understand the consumers' motivations for its use, especially in tertiary students who are presumed to be at a higher risk due to seeking out caffeine's well-known cognitive benefits. The public health consequences of caffeine consumption can only be determined once data is available on the amount of caffeine currently being consumed by New Zealanders, and New Zealand-based studies that have examined caffeine consumption are limited.

Aim: The aim of this study was to examine the caffeine consumption habits of tertiary students in New Zealand; their motivations for use, and experiences across a broad range of caffeine products.

Method: A previously designed caffeine consumption habits questionnaire (CaffCo) was administered to 317 tertiary students via the online survey software, Qualtrics.

Results: Of the total dataset, 99.1% (n= 314), consumed at least one source of caffeine in their diet. The caffeine sources with the highest prevalence of use were chocolate (81.7% of participants), coffee (76.3%) and tea (71.6%). Motivations for consumption appear to differ between various caffeine sources. In caffeine consumers, the median estimated daily caffeine consumption was $146.73 \text{ mg} \cdot \text{day}^{-1}$ (n= 314), or $2.25 \text{ mg} \cdot \text{kgbw}^{-1} \cdot \text{day}^{-1}$ (n= 281), with coffee contributing 61.4% to the total daily caffeine consumption. An estimated 14.3% (n= 45) of caffeine consumers exceeded a suggested 'safe limit' of $400 \text{ mg} \cdot \text{day}^{-1}$, where cigarette smoking was the only participant demographic/characteristic which increased the likelihood of exceeding this level. Caffeine was co-ingested with alcohol by 38.5% (n= 122) of the participants, and those with paid employment or those who smoked cigarettes were more likely to do so. The

majority of caffeine consumers (84.7%, n= 265) reported experiencing at least one adverse symptom post caffeine consumption, 64.2% reported being dependent on at least one caffeine source, and 47.3% (n= 152) of total participants reported experiencing at least one withdrawal symptom in the past.

Conclusions: These findings provide critical information for implementing caffeine-related risk-reduction strategies for New Zealand tertiary students.

Key words: consumer, harm, energy drinks, coffee, health-risk

Acknowledgements

First off, I would like to thank my amazing supervisors; Dr Kay Rutherford-Markwick, Dr Ajmol Ali and Dr Carol Wham, for having confidence in me and providing me with support and guidance whenever I needed it, whilst also allowing me to work at my own pace. I truly couldn't have asked for better supervisors!

Secondly, a big thank-you to Karli Rowe, Jackson Chien and Shampa De for offering their time to help out with data collection for this project. Also, thank-you to Daniel Gordon for providing me with the gear I needed to set up my data collection stands, and to Austen Ganley for organising permission to set-up at one of the data collection locations.

I also want to take this opportunity to show my appreciation to everyone who took the time to participate in this study, whom without, this project would not have been possible.

Finally, a big thankyou to my family, my friends and my classmates for their motivation and never-ending support over the past two years.

Table of Contents

Abstract.....	i
Acknowledgements.....	iii
List of Tables.....	ix
List of Figures.....	xii
List of Abbreviations.....	xiv
List of Appendices.....	xvi
Chapter 1.....	1
1.0 Introduction.....	1
1.1 Background.....	1
1.2 Study Justification.....	5
1.3 Purpose of the Research Study.....	6
1.3.1 Aim.....	6
1.3.2 Objectives.....	6
1.4 Structure of the Thesis.....	7
1.5 Researcher’s Contributions.....	8
Chapter 2.....	9
2.0 Literature Review.....	9
2.1 Introduction.....	9
2.2 Background and History of Caffeine.....	9
2.3 Caffeine Content of Dietary Sources.....	11
2.4 Caffeine Pharmacokinetics.....	15
2.4.1 Absorption and Distribution.....	15
2.4.2 Metabolism and Elimination.....	16
2.5 Caffeine Pharmacodynamics.....	18

2.5.1	Caffeine as an Adenosine Antagonist.....	18
2.5.2	Effects of Caffeine.....	20
2.5.2.1	Mood and Cognition.....	20
2.5.2.2	Sleep and Fatigue.....	21
2.5.2.3	Anxiety.....	23
2.5.2.4	Physical Performance.....	23
2.5.2.5	Cardiovascular Implications.....	25
2.5.2.6	Other Effects.....	26
2.6	Caffeine Tolerance/ Dose Adaptation.....	28
2.7	The Role of Genetics.....	30
2.7.1	CYP1A2.....	31
2.7.2	ADORA2A.....	32
2.8	Recommendations for Caffeine Intake.....	34
2.9	Regulations and Legislations.....	37
2.10	Caffeine Dependency, Withdrawal and Intoxication.....	42
2.11	Consequences of Caffeine Overdose.....	45
2.11.1	Caffeine and Alcohol Co-ingestion.....	47
2.12	Caffeine Consumption Levels and Patterns.....	50
2.13	Factors Influencing Caffeine Consumption.....	52
2.13.1	Functional Expectations and Intrinsic Factors.....	53
2.13.2	Sociocultural and Environmental Factors.....	55
2.14	Summary of the Literature.....	57
	Chapter 3.....	58
	3.0 Methods.....	58
3.1	Introduction.....	58

3.2	Ethical Approval.....	58
3.2.1	Informed Voluntary Consent.....	58
3.2.2	Participant Confidentiality.....	59
3.3	Participants.....	59
3.3.1	Recruitment.....	59
3.3.2	Sample Size.....	62
3.3.3	Selection Criteria.....	63
3.4	Data Collection.....	64
3.4.1	Study Locations.....	64
3.4.2	Questionnaire.....	64
3.5	Data Storage	65
3.6	Data Handling and Statistical Analysis.....	65
	Chapter 4.....	68
4.0	Results.....	68
4.1	Participants.....	68
4.2	Sources of Caffeine in the Diet.....	74
4.3	Reasons for the Consumption of Caffeine-Containing Products.....	91
4.4	Reasons for Not Consuming Caffeine-Containing Products.....	99
4.5	Co-ingestion of Caffeine and Alcohol.....	101
4.6	Estimated Daily Caffeine Consumption.....	104
4.7	Daily Caffeine Intakes Exceeding the ‘Adverse Effect Level’ ($3 \text{ mg} \cdot \text{kgbw}^{-1} \cdot \text{day}^{-1}$).....	119
4.8	Daily Caffeine Intakes Exceeding the Suggested ‘Safe Limit’ ($400 \text{ mg} \cdot \text{day}^{-1}$).....	120
4.9	Perceived ‘Adverse Symptoms’ Post Caffeine Consumption.....	121

4.10	Caffeine Dependence.....	126
4.11	Withdrawal Symptoms.....	126
Chapter 5.....		130
5.0	Discussion.....	130
5.1	Overall Caffeine Consumption Habits.....	130
5.2	Main Sources of Caffeine Consumed and Contribution to Total Caffeine Intake.....	131
5.3	Prevalence of Consumption in Different Groups and Reasons for Consumption by Each Type of Product.....	133
5.4	Estimated Daily Caffeine Consumption and Caffeine-Related Risk.....	140
5.5	Experienced Regarding Caffeine Consumption.....	142
Chapter 6.....		144
6.0	Conclusion.....	144
6.1	Summary of Results/ Main Findings.....	144
6.2	Strengths.....	144
6.3	Limitations.....	145
6.4	Use of the Findings.....	146
6.5	Future Directions.....	147
References.....		148
Appendices.....		170

List of Tables

Table 1.1:	Researchers' contributions to the thesis study.....	8
Table 2.1:	Caffeine content of food and beverages in New Zealand.....	12
Table 2.2:	Recommendations for daily caffeine intake from around the world.....	35
Table 2.3:	Regulations surrounding caffeine content in New Zealand Products.....	39
Table 2.4:	Clinical diagnoses related to caffeine use.....	43
Table 4.1:	Age group and gender of the participants.....	69
Table 4.2:	Body Mass Index of participants by gender and age group categories (n= 263).....	71
Table 4.3:	Body Mass Index categories according to gender and age group (n= 263).....	72
Table 4.4:	Participant characteristics (n= 317).....	74
Table 4.5:	Frequency of consumption of caffeine-containing products.....	76
Table 4.6:	Comparison of consumption of caffeine sources by gender.....	78
Table 4.7:	Comparison of consumption of caffeine source by age group.....	79
Table 4.8:	Comparison of consumption of caffeine sources by BMI category.....	81
Table 4.9:	Comparison of consumption of caffeine sources by living situation.....	83
Table 4.10:	Comparison of consumption of caffeine sources by employment status.....	84
Table 4.11:	Comparison of consumption of caffeine sources by smoking status.....	85

Table 4.12:	Comparison of consumption of caffeine sources by participation in sports.....	86
Table 4.13:	Significant relationships between consumption of different caffeine sources	88
Table 4.14:	Significant relationships between the amounts of the different caffeine sources consumed.....	90
Table 4.15:	Co-ingestion of caffeine and alcohol by participant demographic and characteristics.....	102
Table 4.16:	Co-ingestion of energy drinks and alcohol by participant demographic and characteristics.....	103
Table 4.17:	Estimated daily caffeine consumption from different caffeine sources by gender (n= 314).....	107
Table 4.18:	Estimated median daily caffeine consumption from different caffeine sources by age group (n= 314).....	110
Table 4.19:	Estimated daily caffeine consumption from different caffeine sources by living situation (n= 314).....	112
Table 4.20:	Estimated daily caffeine consumption from different caffeine sources by working status (n= 314).....	115
Table 4.21:	Estimated daily caffeine consumption from different caffeine sources by smoking status (n= 314).....	118
Table 4.22:	Estimated daily caffeine consumption from different caffeine sources by participation in sport (n= 314).....	119
Table 4.23:	Likelihood of reporting at least one ‘adverse symptom’ post consumption of a caffeine source according to regularity of consumption (n= 317).....	123

Table 4.24:	Perceived participant symptoms post consumption of different caffeine sources.....	125
Table 4.25:	Median daily caffeine intake vs perceived participant adverse symptoms (n= 314).....	126
Table 4.26:	Median estimated daily caffeine intake expressed on a per kg body weight basis vs. perceived participant adverse symptoms (n= 314).....	127
Table 4.27:	Proportion of participants who reported dependence on caffeine sources.....	128

List of Figures

Figure 2.1:	Chemical structure of caffeine and adenosine.....	19
Figure 3.1:	Participants' study involvement summary	61
Figure 4.1:	Flow diagram of participant recruitment and inclusion/exclusion in the study.....	68
Figure 4.2:	Ethnicity of the participants (n=317).....	70
Figure 4.3:	Percentage of participants who consume each caffeine source (n= 317).....	75
Figure 4.4:	Stacked bar graph showing 4 point Likert scale responses to reasons for tea consumption (n= 227).....	91
Figure 4.5:	Stacked bar graph showing 4 point Likert scale responses to reasons for coffee consumption (n= 242).....	92
Figure 4.6:	Stacked bar graph showing 4 point Likert scale responses to reasons for chocolate consumption (n= 259).....	93
Figure 4.7:	Stacked bar graph showing 4 point Likert scale responses to reasons for kola drink consumption (n= 156).....	94
Figure 4.8:	Stacked bar graph showing 4 point Likert scale responses to reasons for energy drink consumption (n= 128).....	95
Figure 4.9:	Stacked bar graph showing 4 point Likert scale responses to reasons for caffeinated RTD consumption (n= 58).....	96
Figure 4.10:	Stacked bar graph showing 4 point Likert scale responses to reasons for caffeine-containing sports supplements consumption (n= 21).....	97
Figure 4.11:	Stacked bar graph showing 4 point Likert scale responses to reasons for caffeine tablet consumption (n= 11).....	98
Figure 4.12:	Reasons for not consuming caffeine-containing products.....	100

Figure 4.13:	Distribution of estimated daily caffeine consumption ($\text{mg} \cdot \text{day}^{-1}$) from the different caffeine-containing dietary sources (n= 314).....	105
Figure 4.14:	Distribution of estimated relative daily caffeine consumption ($\text{mg} \cdot \text{kgbw}^{-1} \cdot \text{day}^{-1}$) by gender (n= 282).....	106
Figure 4.15:	Distribution of estimated total daily caffeine consumption ($\text{mg} \cdot \text{day}^{-1}$) by age group (n= 314).....	108
Figure 4.16:	Distribution of estimated relative daily caffeine consumption ($\text{mg} \cdot \text{kgbw}^{-1} \cdot \text{day}^{-1}$) by age group (n= 282).....	109
Figure 4.17:	Distribution of estimated total daily caffeine consumption ($\text{mg} \cdot \text{day}^{-1}$) according to working status (n= 314).....	114
Figure 4.18:	Distribution of estimated relative daily caffeine consumption ($\text{mg} \cdot \text{kgbw}^{-1} \cdot \text{day}^{-1}$) by working status (n= 282).....	114
Figure 4.19:	Distribution of estimated total daily caffeine consumption ($\text{mg} \cdot \text{day}^{-1}$) by smoking status (n= 314).....	116
Figure 4.20:	Distribution of estimated relative daily caffeine consumption ($\text{mg} \cdot \text{kgbw}^{-1} \cdot \text{day}^{-1}$) by smoking status (n= 282).....	117
Figure 4.21:	Perceived ‘adverse symptoms’ post consumption of caffeine (n= 314).....	122
Figure 4.22:	Withdrawal symptoms after stopping consumption of caffeine in the diet (n= 317).....	129

List of Abbreviations

ADORA2A	Adenosine 2a receptor gene
AmED	Alcohol mixed with Energy Drinks
AMP	Adenosine monophosphate
ATP	Adenosine triphosphate
BMI	Body Mass Index
CaffCo	Caffeine consumption habits questionnaire
CHD	Coronary Heart Disease
CNS	Central Nervous System
CVD	Cardiovascular disease
CYP1A2	Cytochrome p450 1A2 enzyme gene
DSANZ	Distilled Spirits Association of New Zealand
DSM-5	Diagnostic and Statistical Manual of Mental Disorders (Fifth edition)
ECF	Extra Cellular Fluid
EEG	Electroencephalogram
EFSA	European Food Safety Authority
FDA	Food and Drug Administration
FSA	United Kingdom Food Safety Authority
FSANZ	Food Standards Australia New Zealand
GRAS	Generally Recognised as Safe
ICD-10	International Classification of Diseases (Tenth edition)
MI	Myocardial Infarction
NIP	Nutrition Information Panel
NNS	National Nutrition Survey
NPC	National Poisons Centre

NSAIDs	Nonsteriodal anti-inflammatory drugs
NZJBA	New Zealand Juice and Beverage Association
NZMPI	New Zealand Ministry for Primary Industries
RTD	Ready to drink alcoholic beverage
SES	Socioeconomic status
SNP	Single Nucleotide Polymorphism
SSB	Sugar-sweetened Beverage
UK	United Kingdom
UL	Upper Limit of intake
USA	United States of America
WADA	World Anti-Doping Agency
WHO	World Health Organisation

List of Appendices

Appendix A:	Massey University Human Ethics Committee approval letter.....	170
Appendix B:	Participant Information Sheet.....	171
Appendix C:	Advertisement poster.....	178
Appendix D:	Paper copy of CaffCo questionnaire.....	179
Appendix E:	Additional results- Frequency of consumption of caffeine-containing products.....	226