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Traditional kava use and body sway: A pilot investigation

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ABSTRACT

Introduction: Kava (*Piper methysticum*), when consumed in traditional influenced settings accompanied with high consumption volumes has been associated with increased body sway, raising concerns about fall risk. However, studies typically utilise pill-styled kava extracts with a lack of understanding regarding experienced naturalistic kava drinkers. This pilot study investigated the effects of naturalistic kava consumption over a six-hour period on postural control.

Methods: Six experienced male kava drinkers consumed 100ml (0.21 US pints) of kava every 10 minutes over six hours in a culturally responsive setting. Postural control was examined at three time points (Pre, Mid, and Post) using a 30-seconds eyes-closed feet-together postural balance test conducted on a 3D force plate. Centre of pressure path length, average velocity, and area of the 95th percentile ellipse data were extracted and compared between time points using a one-way repeated measures ANOVA.

Findings: There were no significant differences in the centre of pressure parameters. Based on the Pre and Post differences for path length and average velocity logged values, this study would require 19 participants to achieve an 80% power and 5% significance level.

Discussion: Our preliminary results do not support that kava consumption negatively affects postural control, findings that appear to be corroborated by a recent neuroscience study. The perceived risks of naturalistic kava consumption with regards to falls may be overstated. Further study on the physiological implications of kava consumption in naturalistic settings is needed to quantify the actual risks.

Key words: Balance, centre of pressure, naturalistic test setting, Pacific, psychopharmacology

INTRODUCTION

Pacific people have been mixing the crushed roots of the kava plant (*Piper methysticum*) with water for over 2000 years to make a drink with great ceremonial, social, and medicinal significance.¹ In kava use sessions, drinkers from Fiji and Tonga commonly each consume 3.6L (0.95 US gallons) of kava beverage over six hours.² With kava use increasing among non-Pacific users who are also reflecting similar use patterns to Fijians and Tongans, particularly in Aotearoa New Zealand, Australia, the USA and selected areas of Europe,³ this volume (3.6L) and time duration provides a 'standard' that has been used in several naturalistic kava use studies.^{2,4,5}

Naturalistic, or traditionally influenced, kava use typically involves users who sit cross-legged on woven mats, serve kava from a centrally located *kumete* (wooden kava bowl) in *bilu* or *ipu* (cups made half coconut shells) and observe Pacific respect-based values that underpin kava use protocol (as represented in Figure 1).¹

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Although regularly consumed at high volumes over many hours, kava is not associated with health risks, addiction or adverse side effects, which is the reason why it is regulated in

Aotearoa New Zealand as a 'food' under the Food Standards Code.^{6,8,9}

Fig. 1. Mixed kava beverage, served from a *tanoa* (kava bowl), being poured in to a *bilo/ipu* (made from half coconut shells), for consumption by an attendee sitting cross-legged on a mat at a kava session. (Photographer, Todd M. Henry, 2019)



Kava's psychotropic effects are reported as soporific relaxant, without causing marked euphoria, hallucinations, or 'intoxication' typical of alcohol or cannabis.^{2,4,10,18} For instance, naturalistic kava consumption did not significantly affect five specific neuroscientific measures of cognitive function (namely Focus, Accuracy, Timing Perception, Plasticity or Fatigue) via a computer-based somato-sensory psychometric measure – only Temporal Order Judgement (TOJ) was impacted.^{4,10,18} TOJ is specifically associated with sequencing, "how well [the] brain is able to keep track of the order of events", or sequencing.¹¹ Moreover, Timing Perception, which measures how well the brain keeps track of time linked to "motor learning, balance and coordination",¹² was not, as stated, impacted. That study, which applied the findings to driver safety following naturalistic kava use, concluded by "suggesting the often-used term 'kava intoxication' is misleading and incorrect."¹⁰

That kava neuroscience study^{4,10,18} was the final stage of a three-part investigation, and one of a very small number to assess cognition associated with naturalistic kava use. Many studies have investigated the effect of kava on anxiety, depression, saccades, and cognition, but almost

all have tested a tablet (or capsule) form of kava; a pharmaceutically manufactured product that is vastly different to naturalistic kava as used in Pacific communities.⁶ For instance, Dr Vincent Lebot,¹³ arguably the world's leading kava ethnobotanists, states,

*We want to promote kava for what it is, a very healthy traditional beverage ... If some companies elsewhere want to extract the active ingredients and prepare some capsules or whatever, this is not called kava any more. Like if you put caffeine in a capsule, you cannot call it coffee; if you put in dry raisin peel, you cannot call it wine, and same for tea. Kava is kava; it is the traditional beverage prepared by cold water extraction of the ground organs of the plant *Piper Methysticum*, and nothing else. We want to protect the geographical origins and the healthy quality kava plants we use here on an original basis.*

Tablet-kava is mostly used as an anxiolytic alternative to Benzodiazapine and/or a sleep aid and is typically ingested at a pharmaceutically recommended daily dose of 60–250mg kavalactones [¹⁴, p. 13]. Most kava tablets typically contain six extracted kavalactones, whereas naturalistic kava contains over 20 lactones together with various other active ingredients, including flavokavains and alkaloids.^{14,15,16} With the increase use of research utilising a water-soluble extract of kava root in tablet form (as opposed to an ethanol and alcohol extraction process), this has encouraged claims that comments such as Lebot's (above), in which he argues kava in tablet form is not technically 'kava', is incorrect. We will return to this theme shortly.

The six kavalactones typically used in many kava tablets are: *dimethoxy-yangonin* (1), *dihydrokavain* (2), *yangonin* (3), *kavain* (4), *dihydromethysticin* (5), and *methysticin* (6). The numerals following each kavalactone is used to present the kavalactone strength sequence (presented in 2.3 Procedure). In contrast to kava tablets, naturalistic kava is often consumed at volumes exceeding 20 times the recommended pharmacological dose.² Additionally, traditionally-influenced naturalistic kava use is typically underpinned by Pacific respect-based cultural values, protocols and use styles, which are likely to influence 'set and setting',¹⁷ or the mindset of the user within the physical kava-use environment.¹⁸ Further, *talanoa*, or "transparent, participatory, and inclusive dialogue"² drive these spaces, together with the use of cultural receptacles and drinking utensils in which users consume kava over multiple hours in settings known by various names, such as *faikava*, *kalapu*, or 'grog sessions',^{2,19} adding to 'set and setting'.

Current understanding of kava psychopharmacology “continues to be chiefly viewed through the lens of inaccurate effect descriptors and research associated with tablet-form kava use, with that latter understanding often applied to, or overlaid on, kava users who drink in naturalistic traditionally influenced settings.” (18, p.80) Consequently, while it is acknowledged that both forms of kava involve water-based extracts of the plant that is commonly called ‘kava’ (*Piper methysticum*), we nevertheless hold the view, and concur with Lebot, that studies conducted using tablet or capsule kava do not reflect the effects of the kava beverage when consumed in naturalistic settings,^{4,6} and therefore kava in these pharmacologically prepared states cannot technically be considered ‘kava’.

Anecdotal reports of naturalistic kava’s impacts on balance and body sway have a lengthy history. In 1879, Henry Moseley, a naturalist who visited Fiji aboard *HMS Challenger*, commented, “[t]he effects [of kava] are very like those of alcohol, in that the gait becomes very unsteady, and the slightest touch sends the person affected off his balance.”²⁰ Others have posited that unsteadiness following lengthy kava use is not “entirely due to properties of the kava”, but more likely sitting cross-legged on the floor for lengthy periods.²¹ Clinical trials to test human balance and body sway following naturalistic kava as consumed at *faikava* and *kalapu* are limited to two dated studies.^{22,23}

In 1985, Garner and Klinger²² used the Maddox Rod test to measure eye movement linked to balance when sitting, standing, and walking²⁴ in one subject following the consumption of two 300ml (total 0.63 US pints) *bilo* of traditionally prepared kava beverage with a rootstock from Fiji. The authors report that at baseline, “The subject was essentially orthophoric [normal condition of balance] ... but developed significant ocular muscle imbalances” following the ingestion of kava (p. 309), speculating that kava acted on the central nervous system and caused muscle paralysis similar to the anaesthetic effect of cocaine. The quantity of kava consumed was very small when compared with typical naturalistic consumption of 3.6L over six hours. Moreover, the kavalactone strength levels were not reported.

In 1993, Prescott and colleagues²³ recorded significant body sway difference (mean [95% confidence interval], 2.3 cm [0.5, 4.1], $p=0.016$) between kava and placebo drinkers. While these results suggest kava negatively affects balance, there are methodological procedures to consider. Notably, the kava was heavily diluted and mixed with orange juice. While kava used in traditional

settings is mixed to varying strength levels,¹ it is not mixed with other substances or beverages.^{4,5,10} Additionally, several participants complained of nausea and declined to consume the recommended study volume. Overall, the effect of kava on postural control remains relatively unexplored.

There is a need for further studies into all areas of kava psychopharmacology linked to naturalistic kava use, as recognised by the World Health Organisation (WHO).²⁵ This pilot study will aid that call through examining the effects of naturalistic kava consumption on postural control using a AMTI AccuGait Optimized force plate.

It was hypothesized that naturalistic kava consumption would increase body sway measures. Preliminary sample size calculations for a full-experimental study (see 5.2 *Participants*) was not achievable due to COVID-19, hence the change in design to a pilot study as defined by Arnold and colleagues²⁶ as a “preliminary investigation ... with a specific hypothesis, objective, and methodology [p. S69] ... [and recognising these] are rarely powered to confidently detect harm with respect to clinically important outcomes.”

MATERIAL AND METHODS

The study was based at Te Huataki Waiora School of Health at the University of Waikato, Aotearoa New Zealand, and guided by the *Pacific Post-development Methodological Framework (PP-dMF)* and the *Faikava Methodology*. The *PP-dMF* draws on post-development theory and respect principles within the Fijian *Vanua Research Framework*, and was developed to ensure the ethical and equitable use of Western-developed, standardised, and normed psychometric measures among Pacific peoples [²⁷, p. 102 also see ⁵]. The *Faikava Methodology* uses naturalistic kava-use settings to collect both quantitative and qualitative data. This method has been used to collect research data for more than 20 years and is recognised by the New Zealand Health Research Council who have funded eight major research projects using this approach.^{4,5} Ethical approval was granted by The University of Waikato’s Human Research Ethics Committee (HREC [Health] #34), and the study abides to the Declaration of Helsinki.

Participants

Based on pre- and post-differences in balance measures following a 12km run,²⁸ 24 participants were needed to achieve 80% power and 5% level of significance (two sided). However, due to COVID-19 lockdown in New

Zealand, this sample size was not achievable; thus, a pilot study was pursued.

Participants were recruited through word-of-mouth. All participants partook in the experiment voluntarily and provided written informed consent. Participants were aged 18 or above, of Pacific Island descent, male, and experienced kava drinkers. Exclusion criteria included inexperience in kava drinking; current or recent neurological, psychological, or physiological conditions; current psychoactive prescribed medications; diagnosed psychotic disorders; and conditions that may affect their ability to complete balance testing. Participants were asked to abstain from drinking kava for four days before the data collection to provide a wash-out period.^{2,4,5}

Procedure

Six participants attended a single data collection session on university campus to take part in a six-hour kava session. Prior to the experiment, the procedures were explained, and participants practiced the postural control task three times to ensure familiarisation.

In preparation for the experiment, dried powdered kava root/basal stump was purchased from a local retailer. One-hour prior to the start of the kava session, a single 36L (9.5 US gallons) batch of kava was mixed to ensure standardisation across the entire test session. That mix utilised a water to kava powder, and mixing duration, also used in other naturalistic kava research data collection settings, (for more details see ^{2,4,5,10}), reflecting a potency typically consumed at a *kalapu* in Aotearoa New Zealand and Fiji.² Several weeks after the testing, a sample of the mixed kava was analysed by The Institute of Environmental Science and Research, Aotearoa New Zealand's national Crown Research Institute. The kava was found to contain no adulterants, with a strength rating of 5% total kavalactones by dry weight, a chemotype of 245163 (i.e., kavalactone strength sequence), and a mean kavalactone content of 115mg per 100ml (0.21 US pints) of kava beverage.

During data collection, the kava was served to participants in *bilo* at precise volumes of 100ml at 10-minute intervals from a centrally located *kumete* (see¹⁸, p. 34). Participants also sat cross-legged on the floor on woven mats. Caffeine-free and sugar-free snacks and water were provided, as would be expected at a typical *kalapu*. Participants could leave the *kalapu* area to stretch their legs or use the toilet. However, participants were required to be present at each drinking and testing interval.

In total, each participant drank 3.6L (0.95 US gallons) of kava. Based on the Crown Research Institute's kava analysis, each participant consumed 4,140mg of kavalactones over the six-hour kava session. After the final post-testing session, participants were provided a meal and transportation home.

Postural balance

Postural measures were assessed at three time points: prior to (Pre), halfway through (Mid), and at the end (Post) of the kava session. Postural balance was assessed using an AMTI AccuGait Optimized force plate, sampling at 150 Hz, and Balance Clinic software v.2.03.00 (Advanced Mechanical Technology Incorporated, Watertown, MA), following similar procedures to those described elsewhere.^{28,29}

For testing, participants stood barefoot in the middle of the force plate, with their feet together, arms by their side, head level, and eyes closed. Participants were instructed to stand as still as possible. Once in the designated position for 3 seconds, 30 seconds of data were recorded and used to extract centre of pressure path length (COP_{path}, cm), mean velocity (COP_{vel}, cm/s), and area of the 95th percentile ellipse (COP_{area95}, cm²). Greater values indicate larger sway area, quicker centre of pressure and sway movements, and larger sway displacements, respectively. These measures were selected as they are the most commonly examined in research, and demonstrate excellent inter-session reliability with corresponding intra-class correlation values of 0.945, 0.95, and 0.90.³⁰ Three 30-second trials were collected at each time point to enhance reliability of measures³¹ with 60 seconds rest given between trials. Data from the three trials at each time point were averaged for statistical analyses.

Data analysis

Mean and standard deviation (SD) values were computed to describe the data. All COP variables violated normality based on Shapiro-Wilk tests (all $p \leq 0.015$). Therefore, data were log-transformed to reduce bias arising from non-uniformity of error and used for interpreting statistical comparisons and computing effect sizes. A one-way repeated measures analysis of variance (ANOVA) was used to identify the main effect of time (Pre, Mid, Post) on COP variables. Identity was the between-subject error term and time the repeated-measure term in all analyses. Mean differences between time points were quantified using Cohen's *d* for paired samples using an average variance with 95% confidence intervals [lower, upper], and interpreted as reflecting small, moderate, and large effect sizes

when reaching thresholds of 0.2, 0.5, and 0.8, respectively, and trivial when <0.2 .³²

Given this was a pilot investigation, post-hoc sample size calculations using the Pre and Post paired differences (mean and SD) were conducted to determine the sample size required to achieve an 80% power and 5% significance level. All statistical analyses were performed using Stata/IC 16.1 for Windows (StataCorp LP, College Station, TX) and Microsoft® Excel® for Microsoft 365 MSO (Version 2109 Build 16.0.14430.20292, Microsoft Corp., Redmont, WA). Statistical significance was set at $p \leq 0.05$.

RESULTS

The mean and SD values for COP_{path} , COP_{vel} , and COP_{area95} for the three time points are shown in Figure 2. There was no significant main effect of time on any of the COP measures ($p=0.204, 0.203$, and 0.809 , respectively). Differences between time points were *trivial* to *small* across measures (supplementary Table S1). Based on the Pre and Post mean and SD differences of the log-transformed data, 19 participants would have been needed to achieve 80% power and 5% level of significance for COP_{path} and COP_{vel} , and an infinite number for COP_{area95} .

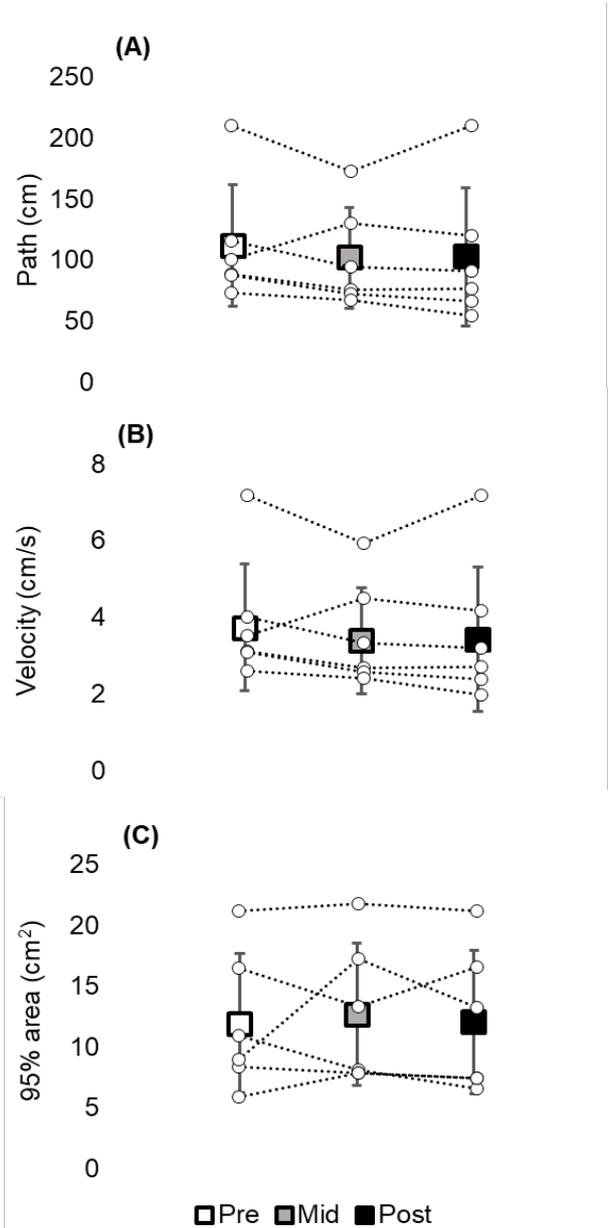
DISCUSSION

This pilot study investigated the effects of kava, when consumed at naturalistic volumes ($>3,000\text{mg/kavalactone}$) during a six-hour traditionally-influenced kava session, on human postural control. This study incorporated novel experimental techniques in kava research: namely, the use of force plates to quantitatively assess postural control.

Data analysis showed no significant change in the three COP measures examined when comparing Pre, Mid, and Post time points. Differences between time points were *trivial* for COP_{area95} , and *small* for COP_{path} and COP_{vel} when comparing Pre to Mid and Post. For the differences in COP_{path} and COP_{vel} measures detected, we would have required 19 participants to achieve an 80% power and 5% significance level: 3.2 times more than the current sample size. Altogether, these findings suggest that a future larger study using the same procedures should include at least 19 participants; could omit extracting COP_{area95} measures; and could examine Pre and Post time

Fig. 2. Centre of pressure (A) path (cm); (B) mean velocity (cm/s); and (C) area of the 95th percentile ellipse (cm²) for Pre, Mid, and Post 6-hour kava session. Squares represent mean values and whiskers represent standard deviations. Circles joined by dashed lines represent individual data. points only given the similarities between Mid and Post measures

for COP_{path} and COP_{vel} , and slightly larger Cohen d effect sizes noted when comparing Post to Pre.



Past studies suggest kava consumption increases body sway,^{22,23} causes ataxic and unsteady gait with an inability to stand,³³ and induces falls.³⁴ Those studies, however, are based on case reports and in-house constructed balance measurement systems with no reported reliability or validity of measures.

Researchers and clinicians often use force plates to track COP measures in quiet stance when studying postural control.^{30,35} These methods are shown to be useful and reliable in assessing postural stability.³⁶ Both COP_{path} ³⁷ and COP_{vel} ³⁸ in an eyes-closed condition have been associated with increased incidence of falls in community-dwelling older adults. Therefore, despite being a pilot study with low participant numbers, the current study is strengthened by its testing procedures and use of research-grade equipment

to examine postural control and potential risk of falls in experienced kava drinkers. Based on our preliminary results, however, kava did not alter postural control in quiet stance.

In fact, the trends in the COP_{path} and COP_{vel} are contradictory to our hypothesis and suggest there may be a decrease, rather than an increase, in postural sway (i.e., reduced COP_{path} and COP_{vel} Mid and Post compared to Pre), which would need a larger sample size to confirm. It is one possibility that naturalistic aqueous kava consumption does not affect static balance despite evidence of muscle relaxant and sedative effects found during *in vitro* and *in vivo* studies.³⁹ Whilst not affecting static balance, it could be that naturalistic kava consumption affects dynamic balance and gait, which were not examined currently and could be assessed using other methods, including the Y-Balance Test, Timed Up and Go Test, Functional Reach Test, and Berg Balance Scale.⁴⁰

The trend towards an improvement in postural control measures throughout the six-hour kava session could be due to the lack of familiarity of participants to balance assessments. The reliability in static COP measures tends to improve with numbers of repetitions or trials recorded.³⁶ To limit the effect of familiarisation on balance measures, all participants completed a familiarisation trial prior to data collection and data at each time point were average across three trials.^{36,41} Furthermore, simple and straightforward instructions were provided to participants.

Interestingly, despite the consistent instructions, participants appeared to approach force plate testing differently. One participant saw it as a competition, while other participants were more nonchalant regarding testing. Wickström and Bendix⁴² describe, “the Hawthorne effect is commonly referred to as an increase in [the] outcome under study - caused by participation in the study” and linked to motivating factors (pp. 366). Additionally, in biomechanics research, the presence of observers⁴³ or testing equipment⁴⁴ can alter performance of individuals. Once participants started drinking kava, they may have felt officially under investigation, wanting to maintain or improve their performances from baseline.

Alternatively, it is common for Pacific kava users to view kava as possessing *mana*, or spiritual power, with some anecdotal commentary suggesting that *mana* is positively efficacious and therefore kava (as possessing *mana*) cannot cause negative effects on the user.¹ It is possible that the Hawthorne effect and spiritual beliefs of participants contributed to the *small*, albeit non-

significant, improvements in postural sway measures associated with the kava drinking session.

An additional factor worth considering is kavalactone action. In a 2017 study, Kautu and colleagues³⁹ stated that although “Pacific Islanders have consumed kava for thousands of years, yet the neurophysiological mechanisms associated with kavalactone metabolism are not fully understood [p.5]”. That comment prefaced an investigation of kavain, one of the six dominant kavalactones (number 4), and kavain’s neurotransmitter modulating action in several species of worm. They report that “kavain induced worm paralysis but not convulsions ... Kavain has been shown to potentiate GABA_A receptor subtypes *in vitro*. Thus, it is possible that the observed kavain-induced paralysis in the worms could be due to altered GABA transmission.” (p. 6). The HPLC analysis undertaken on the kava sample by ESR showed a chemotype of 245163, positioning kavain second on the strength sequence. Admittedly our pilot study used human participants and not worms, however Kautu et al.’s work used worms aimed at understanding kavalactone action in humans. Therefore, it would be expected that the high level of kavain consumed by our participants would have induced a level of paralysis and encourage imbalance and body sway. This did not occur.

A final consideration is that a placebo condition was not used here, as done elsewhere.²³ Although the absence of a placebo condition may limit study sensitivity, Aporosa and Tomlinson⁴⁵ argue that placebo conditions are not suitable for kava research conducted in naturalistic settings. This argument is based on kava’s spiritual and ceremonial significance, which prevents deception associated with placebo.^{1,2,18} Further, the taste and effects of kava are unique and well known to experienced kava drinkers, further limiting placebo use.^{2,13,18} Finally, experienced drinkers are necessary to investigations requiring high typical naturalistic use volumes to ensure study completion.^{2,18}

This study, albeit a pilot, adds to a wider body of work focused on assessing cognition following naturalistic kava use^{2,4,10,18} together with the WHO’s²⁵ call for greater understanding on all areas of kava psychopharmacology. The prior work also utilised the *Pacific Post-development Methodological Framework* and the *Faikava Methodology*, involved similar kava volumes, and tested six cognitive faculties of which one, Timing Perception, also measured balance.^{4,6,10} Contrary to hypothesis, kava drinking significantly affected only one of the cognitive faculties tested: Temporal Order Judgement (TOJ). TOJ is linked

to sequencing and the tracking of event order,¹¹ and not balance. Conversely, three of the other cognitive functions (i.e., Accuracy, Plasticity and Focus), which were unaffected by kava^{4,6,10} have been linked with movement and control.^{46,47,48} Therefore, these previous findings appear to support the lack of altered postural control with kava consumption over many hours found here. When added to that wider body of work, and particularly work that sought to understand kava's effects on driver safety, the findings of this kava balance pilot study also add support toward kava having minimal impact on several faculties critical to safe driving.

CONCLUSION

This pilot study investigated the effects of naturalistic kava consumption on static postural control in regular kava drinkers. Results suggest that kava does not impair postural control as measured using a 30-seconds eyes-closed static stance balance task. This study informs future research in terms of sample size requirements, relevant COP variables to investigate, and suitable assessment time points, as well as proposes alternative postural control measures (e.g., dynamic balance and gait).

These preliminary results also support work showing kava is a safe substance that exhibits minimal side-effects, although requires more extensive research to better understand the effects of naturalistic kava on the various components of postural stability. Given the pilot results derive from experienced kava drinkers, results should not be generalised to inexperienced kava users until further studies are conducted. Admittedly "Clinical effects documented in pilot trials should be reported with caution to avoid undue enthusiasm or pessimism about unstable estimates."

Highlights:

- Kava is a culturally significant drink for Pacific people
- Anecdotal reports describe impaired balance following high traditional use volumes
- Postural control was tested during and following kava use in a pilot study
- Contrary to hypothesis, results do not show that kava negatively affects postural control

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Conflicts of interest/Competing interests: The first-author, Dr. Apo Aporosa, declares he has

been drinking kava for more than 20 years and that kava and the kava culture are an important part of his Fijian ancestry and cultural practice. The third-author, Harvey Aughton, of European ancestry, declares kava use comprises an aspect of his socialisation.

Availability of data and material

The research data is available upon reasonable request.

Authors' contributions (to this paper)

The lead author, AA, supervised the Masters study, oversaw the *faikava* data collection environment and cultural requirement, and assisted in the writing of this paper (approx. 45%) The second-author, KH-L, advised on the study design and data collection methods, conducted the analysis, informed discussion on the interpretation of that data, and contributed to the writing and explanation of this paper (approx. 40%). The third-author, HA, led the research project as part of his Masters study and assisted with the writing of this paper (approx. 15%).

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