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Project Title: Developing an Evidence-Based Smartphone Application for Monitoring and Promoting Athletes' Awareness to Unintentional Doping

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Introduction of the Project

Situation of Unintentional Doping

A majority of the doping cases can be attributed to intentional doping, however there has been increasing incidences of claims or declarations that doping occurred unintentionally or inadvertently. Such anecdotal reports have received considerable attention in the public and media. Unintentional doping could happen to "clean" athletes who accidentally intake food, supplements, or medications that contain banned performance-enhancing substances (Chan, Ntoumanis, et al., 2015b). This is particularly true because athletes nowadays can easily access supplements or energy products worldwide through online shopping; for example, a recent study showed that a proportion (16.5%) of the dietary supplements available online contain substances prohibited by WADA (Baume, Mahler, Kamber, Mangin, & Saugy, 2006). If athletes have inadequate knowledge to identify or be aware of the presence of performance-enhance substances in these products, there is a heightened risk of unintentional doping in their daily life (Chan, Ntoumanis, et al., 2015b). The majority of research investigating psychological and personal factors that are associated with athletes' intentions and actual behaviours of doping is growing (Ntoumanis, Ng, Barkoukis, & Backhouse, 2014); however, existing perspectives do not account for the psychological processes of unintentional doping as it is assumed that doping is an intentional behaviour that depends on athletes' conscious decision-making and moral values (Chan, Ntoumanis, et al., 2015b). A recent WADA funded meta-analysis of psychological factors of doping (Ntoumanis et al., 2014; Ntoumanis, Ng, Barkoukis, & Backhouse, 2013) has therefore been criticised as doping violations may be unintentional (Chan, Ntoumanis, et al., 2015b).

Psychological Research of Unintentional Doping

In the light of resolving this research gap, a focus group interview on young athletes' attitudes and beliefs of doping in sport provided preliminary evidence regarding the challenges young athletes encounter in understanding the ingredients lists printed on the packing of food, drinks, supplements, or medications. It was noted that in order to prevent unintentional doping, athletes had to be extremely vigilant in checking the ingredients list to the most updated information (Chan, Hardcastle, and colleagues, 2014). This initial study was one of the first studies to suggest that the avoidance of unintentional doping requires a lot of conscious effort and persistence, even more importantly, its effectiveness and persistence may also be dependent on the self-regulatory capabilities of athletes (Chan, Hardcastle, et al., 2014).

Following this initial qualitative study, Chan and colleagues also applied the self-determination theory (Deci & Ryan, 1985) to examine if motivation of the avoidance of unintentional doping was related to young athletes' behavioural response when a suspicious food product was offered, and if they were linked to self-reported behavioural adherence of the avoidance of unintentional doping, and doping intention. It was found that athletes who held high autonomous motivation in the avoidance of unintentional doping (i.e. avoid doping because it is consistent with their life goals, personal values and responsibilities) were more likely to check whether or not the ingredients list of food product specified banned performance-enhancing substances, and they were also more likely to report lower doping intention (Chan, Donovan, et al., 2014). In contrast, athletes who held high controlled motivation in the avoidance of unintentional doping (i.e., avoid doping because of the negative consequences, or to reduce the feeling of guilt of social disapproval for not doing so) were more likely to avoid doping by refusing to take or eat the lollipop, and they were also more likely to report higher behavioural adherence to the avoidance of unintentional doping. Overall, the results showed that both autonomous motivation and controlled motivation of the avoidance of unintentional doping were positively related to certain anti-doping behavioural outcomes. From a theoretical point of view, autonomous motivation was deemed more favourable because athletes who hold this type of motivation truly seek to familiarise, understand, or learn about the specific banned ingredient content in relation to the WADA prohibited list (Chan, Donovan, et al., 2014).

Other than the self-determination theory, other theoretical frameworks, including the strength-energy model of self-control (Baumeister, Bratslavsky, Muraven, & Tice, 1998) was also investigated in the context of unintentional doping. These studies also identified possible psychological mechanisms associated with the avoidance of unintentional doping. In particular, motivation and self-reported behavioural adherence of the avoidance of unintentional doping and trait self-control from the strength energy model of self-control (Chan, Ntoumanis, et al., 2015b; Chan, Hardcastle, et al., 2015; Chan, Lentillon-Kaestner, et al., 2015).

This preliminary evidence has led us to speculate that the promotion of athletes' awareness to the avoidance of unintentional doping might be most effective when manipulating the psychological variables that are most salient with behavioural patterns of the avoidance of unintentional doping (Chan & Hagger, 2012; Hagger, 2009). As addressed in the research of Chan, Ntoumanis and colleagues (2015b), these behaviours might include learning and updating correct knowledge of banned substances and paying extra attention to the food, drinks, supplements, and medication that are suspected to contain banned performance enhancing substances.

Evidence-Based Education Against Unintentional Doping

In light of such, Chan, Hagger and colleagues' research on the avoidance of unintentional doping built the first evidence-based educational website www.playingclean.com.au that synthesised research knowledge into practical information comprehensive to young athletes, coaches, and other sport professionals. The website has been highly regarded in Australia for anti-doping education purposes, but it is important that scientific evaluation is made on its effectiveness in changing athletes' awareness, behaviours, intentions, and associated psychological factors of the avoidance of unintentional doping.

The development of this evidence-based educational website leads us to the current research. Other than having these evidence-based information online, we decided to embed this into a smartphone application because of the increasing popularity, accessibility, and usage of smartphones among athletes in this generation. Moreover, the aim of the current study was to examine if the evidence-based educational materials will be effective in changing the psychological and behavioural factors of the unintentional doping.

Aim of The Present Project

To this end, over the course of three years, we (i) developed a smartphone application using research findings, educational materials, and assessment tools of recent empirical studies about psychological factors (e.g., self-control, motivation, beliefs, attitudes, and intention) of the avoidance of unintentional doping in phase 1; and (ii) in phase 2, we tested the effectiveness of the smartphone application via a randomised controlled trial among athletes in two countries, with 1,3 and 6 months follow-up.

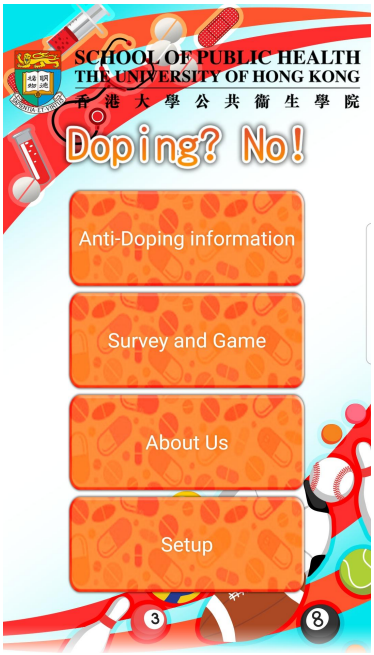
Phase 1 of Our Project

Overview of Phase 1

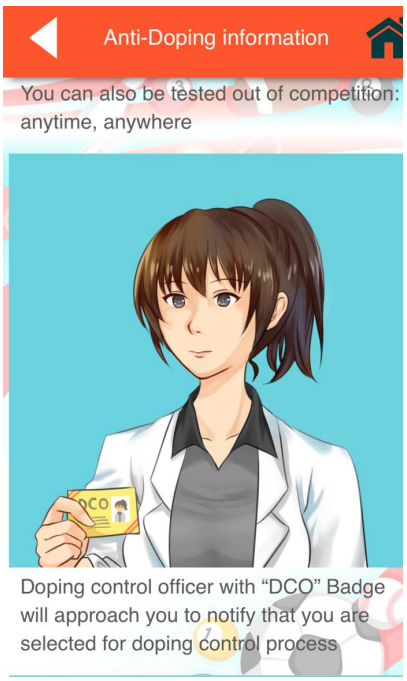
In phase 1, we successfully developed a smartphone application (app) in the context of monitoring and promoting athletes' awareness of unintentional doping. Inside this new and innovative application, we have implemented both psychological assessment and educational materials and the contents were translated and made available in both English and Chinese.

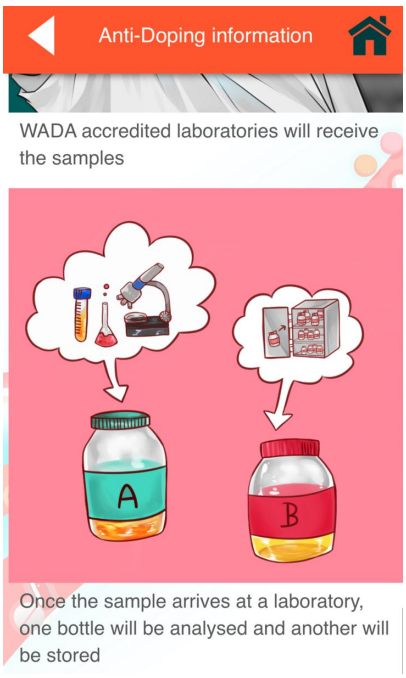
Educational Materials within the App

The educational materials within the smartphone application made reference to the construction of the first evidence-based anti-doping education website www.playingclean.com.au. The content included a series of behavioural change strategies for the avoidance of unintentional doping that align closely to the techniques (e.g., information provision, identifying barriers/ problem resolution, review of behavioural/outcome goals, prompt practice) classified by the taxonomy of behaviour change (Hagger, Keatley, & Chan, 2014; Michie et al., 2011). The presentation and content of the information was specifically designed to manipulate psychological variables that are shown to be associated with the avoidance of unintentional doping (i.e., motivation, attitude, intention).



Other than taking the information directly from www.playingclean.com.au, to enhance understanding and interpretation, we also included original digital graphics for the introduction of "what is doping", examples of which are presented below.





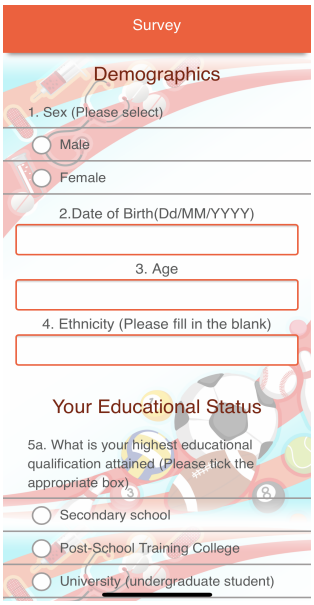
Psychological and Behaviour Assessments inside the App

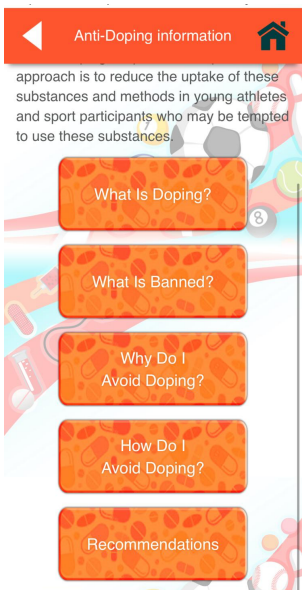
The innovative app had the function of sending pop-up notifications to individual participants telling them that it is time to complete an assessment at 1-month, 3-months and 6-months post baseline assessment. Having the assessments inside the application can benefit participants as they do not need to travel for testing and can do it themselves at their own convenience.

Assessments within the app not only measured basic athlete demographic information such as gender, age, educational status, sport experience, but we also measured the psychological aspects of doping avoidance.

Included psychological assessments were derived from scales that have been previously validated that measured: different forms of motivation, namely autonomous, controlled and amotivation (Treatment Self-Regulation Questionnaire; Levesque et al., 2007), self-control (Trait Self-Control Questionnaire; Tangney, Baumeister, & Boone, 2004), and self-reported behavioural adherence to the avoidance of doping (Self-reported behavioural adherence to the avoidance of doping scale; Chan, Donovan, et al., 2014).

These measures were included as they were previously speculated to have possible psychological mechanisms associated with the behavioural avoidance of unintentional doping.





In addition to the traditional established psychometrics, we have also developed and introduced 2 new assessments of unintentional doping. The first new assessment drew upon the original concept of a Single Category-Implicit Association Test (SC-IAT) and placed it inside an app. The SC-IAT is a timed sorting task, which aims to measure the strength of an association between a stimuli (in this case, doping) and superordinate categories (i.e. good/bad, like/dislike) via participant's reaction times. Faster reaction times are sought to have stronger associations between the categories. More importantly, as this is an objective assessment compared to traditional self-report, it is much less susceptible to socially desirable results or "faking" the responses to fit from social norms. This is particularly useful in our current context of doping as it is socially undesirable.

Given its advantageous nature, our current investigation placed this reaction timed task in an application, allowing even easier access globally. The app then subsequently records participants' responses and time taken to answer in milliseconds. The mobile application of the SC-IAT is now available online (http://anti-doping.derwinchan.com/implicitassociationtest.html), and the user manual of this application is now published in The British Journal of Sports Medicine (Tang et al., 2022).

Our second new assessment, the Canned Beverage Sorting Task, on the other hand, aimed to mimic daily life scenarios by presenting athletes with images of hypothetical canned beverage that may or may not contain banned substances (right screenshot below). The task was developed on the basis of the observational checklist of unintentional doping behaviour from the study Chan et al (2014). In short, this task reflected the extent to which individuals accurately identify (and say no to drink) canned-beverages that contain banned substances and canned-beverages that do not have a clear ingredients list. The mobile application of the Canned Beverage Sorting Task is now available online (http://www.derwinchan.com/Canned-Beverage-Sorting-Task-mobile-devi).

In both these tasks, athletes were asked to categorize the stimuli that appeared in the middle as fast and accurately as possible (below left is the SC-IAT screenshot and right is the Canned beverage sorting task).

Content and Evaluation of the App between Treatment and Control Group

As set out in our initial proposal, our subsequent phase 2 results section aimed to investigate whether evidence-based educational materials are effective in changing the psychological and behavioural factors of unintentional doping. Following the protocol of a randomised controlled trial, participants were randomly divided into the treatment or control group by computer balloting.

There were subsequently two versions of the app, one for the treatment group and one for the control group. The treatment group were offered the smartphone application with educational material and psychological assessment whilst the control group were offered another version of the smartphone application with psychological assessment only. Both groups completed the application's pre-set assessments at 0-months (Baseline), 1-month, 3-month and 6-month timepoints.

Phase 2 of Our Project

Overview of Phase 2

In phase 2, we proposed to test the effectiveness of the smartphone application that was developed in phase 1 by using a randomised controlled trial among athletes in at least two different countries. All participating athletes was invited to complete assessments at 0-months (baseline), 1-month, 3-months and 6-month intervals to assess the effectiveness of the smartphone application longitudinally and its ability to be sustained over time.

Methodology

Design

The current study is a longitudinal randomised controlled trial. Other than baseline assessments, participants were also invited to complete subsequent follow-up assessments at 1-month, 3-months and 6-months. Assessments at all timepoints were identical.

Materials

The current study utilized 3 previously validated self-report questionnaires and asked participants to complete two sorting tasks. Details of each individual questionnaire/task can be found below.

Self-Reported Adherence to the Avoidance of Doping Scale
The treatment self-regulation questionnaire in the avoidance of doping in sport measured self-reported behavioural adherence to the avoidance of doping. There were a total of 7-items on a 7-point Likert scale (Chan, Donovan et al., 2014; Chan et al., 2015a). There were two subscales within this questionnaire: frequency (3-items, Likert ranging from 1, "Never to 7 "Very Often") , and effort (4-items, Likert ranging from 1, "Minimum Effort" to 7 "Maximum Effort"). The current study demonstrated excellent reliability ($\alpha > 0.93$) across all time-points.

Treatment Self-Regulation Questionnaire for the Avoidance of Doping in Sport
The Treatment Self-Regulation Questionnaire is based off of the self-determination theory and measured tree types of motivation, namely, autonomous motivation (6-items), controlled motivation (6-items), and amotivation (3-items) on a 7-point Likert Scale ranging from 1, "Not True at all" to 7, "Very True" (Levesque et al., 2007). The current study demonstrated good reliability ($\alpha > 0.74$) across all time-points.

Trait Self-Control Questionnaire
Trait self-control questionnaire measures an individual's capacity of self-control according to the strength-energy model and has 13-items on a 4-point Likert scale ranging from 1, "Not at all" to

4, “Very much” (Tangney et al., 2004). The current study demonstrated excellent reliability (α >.83) across all time-points.

Canned Beverage Sorting Task

Other than psychological variables, our smartphone application also embedded a new canned beverage sorting game. Within this game, participants were presented with a canned beverage. Depending on its displayed ingredients table (if it is present, or whether there are banned substances displayed on the ingredients), it could have been sorted as “can drink” or “cannot drink” (pictured below).

A display screen also reminded participants at the beginning of the task that the canned beverage picture can be zoomed in with the pinching motion, should they need to have a closer look. If their response was correct, the next question will appear, however if the response was incorrect, instant feedback was given by a screen saying “wrong”.

This task aimed to mimic a real-life daily situation to see whether athletes would (1) check the ingredients list prior to consumption and (2) make the correct decision based on the ingredients list. For familiarization, participants were given a practice trial prior to the test phase. The test phase totalled 32 canned beverages that was sorted. Scoring were calculated based on sum of correct answers.

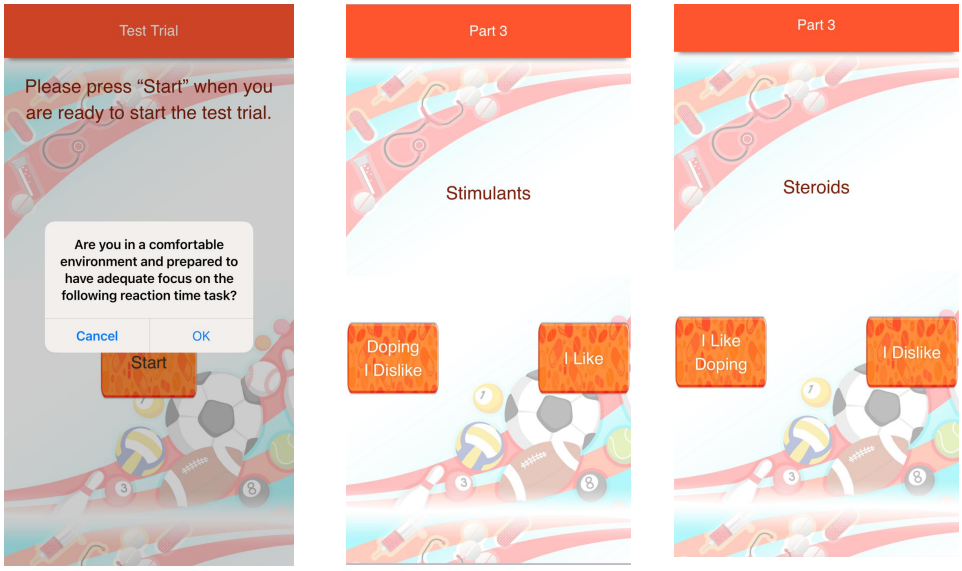
SC-IAT

The SC-IAT was also reaction timed word-sorting task. In this test, a word appeared in the middle of the screen, and participants were told to sort it as quickly and as accurately as possible. A total of 48 words were sorted and the words appeared randomly. Keywords that require sorting in the current study were based on previously established forms of IAT in the context of doping (Chan et al., 2017; Chan et al., 2018).

There were a total of 2 blocks in the SC-IAT. In the first block, “I Like/Doping” were on the left, whilst “I Dislike” was on the right. In the second block, “I Like” was on the left and “I Dislike/Doping” was on the right. This 2-block version of the SC-IAT was based off previous

studies in the context of doping (Chan et al., 2017, Chan et al., 2018) and the layout of both blocks can be found in the picture below. If participant's response was correct, the next question will appear, however if their response was incorrect, instant feedback was given by a screen that said "wrong". As we had two blocks, it was counterbalanced across participants to ensure that there were no order effects. Prior to the test-phase, participants were allowed a practice trial of both blocks to familiarize themselves with the task.

To ensure accuracy in the reaction time paradigm and that the participant was free from distractions, participants were asked to confirm that they were in a comfortable environment before beginning a reaction timed task (as pictured below).



Our results were calculated using the reaction times of the correct trials only. Following the recommendations of Chan and colleagues (2017, 2018), only the reaction times between .35 to 3.0 seconds were taken into consideration as outliers were not a measure of automatic implicit responses. Moreover, to calculate a difference score (D-score), the difference of the average reaction time between Doping/I Like v. Doping/I Dislike was divided by the standard deviation of the reaction times of all correct responses in both blocks. As such, a higher positive score (i.e. D-score greater than 0) indicated a stronger association between the target concept (i.e. doping) and the attribute "I like", reflecting greater positive implicit attitude towards doping. On the other hand, a lower negative score (D-score is negative) indicates a stronger association between the doping keyword and the attribute of "I dislike", reflecting a greater negative implicit attitude towards doping (Greenwald, Nosek & Banaji, 2003).

Participants

We aimed to collect a total of 600 participants in at least 2 different countries to complete assessment at baseline. Participants that fitted our inclusion criteria were invited to participate in the current study.

The inclusion criteria included all elite or sub-elite level athletes aged 16 or above who have participated in organised sport training and competitions (at least regional level) for 2 or more years. Moreover, as targeted sports of WADA, and sports that are recognised by the Association of IOC Recognised International Sports Federations (ARISF), athletes who participated in other sports (e.g., cheerleading, surfing, chess) of which are not monitored by these two organisations, were subsequently excluded.

Procedure

Eligible participants were randomly divided into the either treatment or control group by computer balloting. The treatment group was offered a version of the smartphone application with educational materials and psychological assessments, whilst the control group was offered another version of the smartphone application with psychological assessments only. After successfully downloading the application, participants were asked to complete the demographic and baseline questionnaires, and sorting tasks on their phone.

After completing the aforementioned baseline measures, participants were reminded to keep the application on their phones for at least 6 months and to complete the follow up assessments when they are prompted at 1 month, 3 months, and 6 months later. All of these assessments were embedded into the smartphone application so that participants can easily access and complete the same questionnaires and task at the latter timepoints.

Data Analysis

Given that the prevention of unintentional doping requires conscious awareness and persistence, the follow-up assessments, although identical, were essential in testing the effectiveness of the educational materials' (and the smartphone application's) sustainability over time.

Data was analysed through the use of a 2x2 Mixed ANOVA to examine the effect of group (treatment group versus control group) and time (baseline, 1 month, 3 months, 6 months) on each of the dependent measure. Moreover independent samples t-tests was also utilized to investigate any specific group differences and to investigate any post-hoc results.

Results

Sample Demographics

We have met our proposed targeted sample size of 600 participants, we have also expanded our reach to also include participants in the United Kingdom (originally Hong Kong and Australia only). Our study successfully recruited 681 (52% male) participants in three countries to complete questionnaire and test assessments at baseline. A break-down of participants by country can be found in Table 1 below.

Table 1. Number of Participants by Country at Baseline

	Australia	Hong Kong	United Kingdom	Total
Participants at Baseline	164	177	340	681

As our study has four time points for assessment: baseline, 1-month, 3-month and 6-months, participant drop-out rate across all follow up timepoints was not considered high in the current study. Merging across all countries, each time point observed at least a 60% respondents rate from the last time point (60.7%, 66.4%, 66.9% respectively).

Additionally, as our participants were randomly split between treatment and control groups, the groups were considered balanced across all time points as there were no greater difference than 15% between the groups across time (see Table 2).

Table 2. Number of participants across time by treatment/control group

	Baseline	1-month follow up	3-months follow up	6-months follow up
No. of participants in Treatment Group	340	195	131	86
No. of participants in Control Group	341	219	144	98
% Difference between groups	.29%	11.59%	9.45%	13.04%

Age range of participants was considered as a good representation. Participants were aged from 15-56 (mean age 28.21, standard deviation 8.43). Other than age, our participant samples also included a representative sample of sport level, with 543 regional, 69 state, 39 national and 23 international athletes (7 did not reveal).

There was also a good representation of different educational background status in the current sample with 97 achieving secondary school, 121 post-school training college, 340 undergraduate university, and 121 postgraduate university (2 did not reveal).

Other than our demographic information, our measured psychological variables means (treatment/control) can be seen in Table 3 below.

Table 3: Mean Score of Psychological Variables

	Baseline	1-Month	3-Month	6-Month
Behavioural adherence to the avoidance	20.56 (20.99/20.14)	22.92 (23.13/22.70)	23.41 (23.88/22.94)	23.50 (23.70/22.30)

of unintentional doping				
Autonomous Motivation	34.43 (34.59/34.27)	34.44 (34.73/34.15)	34.35 (34.62/34.08)	34.32 (34.56/34.07)
Controlled Motivation	30.75 (31.13/30.36)	31.01 (31.55/30.47)	30.91 (31.24/30.58)	30.91 (31.31/30.51)
Amotivation	9.09 (9.29/8.89)	9.01 (9.15/8.87)	9.20 (9.31/9.08)	9.11 (9.11/9.11)
Self-Control	36.94 (36.54/37.34)	36.66 (36.62/36.69)	36.49 (36.26/36.72)	36.63 (36.32/36.93)
Can Sorting Game (milliseconds)	27.82 (27.61/28.05)	28.61 (28.34/28.88)	28.79 (28.58/28.98)	28.81 (28.51/29.10)
SC-IAT (milliseconds)	-.38 (-.37/-.38)	-.37 (-.40/-.34)	-.34 (-.38/-.31)	-.35 (-.40/-.32)

* Total means displayed and in brackets, treatment and control means respectively displayed

Participant Psychological Components - No Baseline Pre-treatment Differences
We conducted several independent samples t-test to determine whether there were any pre-treatment differences in psychological variables between treatment and control groups.

At baseline, the treatment and control groups did not differ on any psychological assessments: Antidoping behaviour frequency ($t(679)=.978$, $p>.05$ (two-tailed)), effort in carrying out Antidoping behaviour ($t(679) = .816$, $p>.05$ (two-tailed)), Autonomous Motivation ($t(679)=.620$, $p>.05$ (two-tailed)), Controlled Motivation ($t(679) = 1.534$, $p>.05$ (two-tailed)), Amotivation ($t(679)=1.141$, $p>.05$ (two-tailed)) and Trait self-control ($t(679) = -1.61$, $p>0.05$ (two-tailed)).

This establishes that there were no significant baseline differences across the treatment and control groups, and that the distribution of study variables were balanced across two groups at recruitment.

Given this, a 2x2 Mixed ANOVA will be utilized in the following examine the effect of group (treatment group versus control group) and time (baseline, 1 month, 3 months, 6 months) on each of the dependent measure.

Behavioural Adherence to the Avoidance of Unintentional Doping

After correcting for participant drop-out across time, a 2x2 Mixed ANOVA was used to investigate the behavioural adherence to the avoidance of unintentional doping.

The results showed that there was significant main effect for behavioural adherence to the avoidance of unintentional doping across our four timepoints $F(2.07, 1403.85) = 72.34$, $p<0.001$, $\eta_p^2=.096$, suggesting that the means across timepoints were different. Looking at the means, this suggests that, regardless of group, there was a significant increase of behavioural adherence to the avoidance of unintentional doping across time.

On the other hand, there was no significant main effect of group (treatment v. control) on behavioural adherence to the avoidance of unintentional doping, $F(1, 679) = .518$, $p>0.05$, $\eta_p^2=0.001$, suggesting that the means of the treatment group and control group were relatively similar. There was also no significant interaction effect between the treatment group and the control group in terms of behavioural adherence to the avoidance of unintentional doping across time $F(2.07, 1403.85)= .749$, $p>0.05$, $\eta_p^2=0.001$. With this, our results indicate that we were unable to find a significant difference between the treatment group v. control group across the duration of 6-months.

Psychological variables: Motivation

After correcting for participant drop-out across time, we investigated autonomous motivation, controlled motivation and amotivation independently through a 2x2 Mixed ANOVA to reveal any between group effects across time.

Autonomous Motivation

Results did not reveal any significant main effect of time $F(2.206, 1497.751) = .331$, $p>0.05$, $\eta_p^2>0.001$, group $F(1, 679) = .977$, $p>0.05$, $\eta_p^2=0.001$ or interaction effect $F(2.206, 1497.751) = .303$, $p>0.05$, $\eta_p^2>0.001$, suggesting that the means between (treatment/control) group and between time were similar.

Controlled Motivation

For controlled motivation, results did not reveal any main effect for time $F(2.40, 1520.79) = 1.08$, $p>0.05$, $\eta_p^2=0.002$, group $F(1, 679) = 3.25$, $p>0.05$, $\eta p^2=0.005$, or interaction effect $F(2.40, 1520.80) =.740$, $p>0.05$, $\eta_p^2=0.001$, indicating that the means between (treatment/control) group across time were similar.

Amotivation

Results did not reveal any significant main effect for time $F(2.09,1419.53) = .926$, $p>0.05$, $\eta_p^2=.005$, group $F(1, 679) = .548$, $p>0.05$, $\eta_p^2=.001$, and interaction effect $F(2.09, 1419.53) = 1.07$, $p>0.05$, $\eta_p^2=0.002$, showing similar means of group across time.

Psychological Variables: Self-Control

The 2x2 ANOVA analysis indicated a significant main effect of time $F(2.2, 1534.80) = 5.481$, $p<.05$, $\eta_p^2=0.008$, and with a significant interaction effect of time and group, $F(2.2, 1534.80) = 3.613$, $p<.05$, $\eta_p^2=0.005$. Given this, no significant main effect of group $F(1,679) = 1.03$, $p>0.05$, $\eta_p^2=0.002$ was found. Post-hoc analysis with Bonferroni correction then showed that there were no specific between group differences and that the significance was due to timepoint differences. On closer inspection of the mean between groups, those in the treatment group had on average lower self-control than the control group at all the timepoints, however this did not reach significance.

Innovative Canned Beverage Sorting Game

The new innovative canned beverage sorting game's test-retest reliability has shown to have excellent reliability with highly significant (all $p<.01$) correlation values of $r= .649$ to $.832$ across all the time points.

After correcting for drop-out participants across time points, we used a 2x2 ANOVA to determine any difference between group effects across time within this task. A significant main effect of time was found $F(1.76, 1194.4) = 49.253$, $p<.01$, $\eta_p^2=0.068$. However, main effect of group $F(1,679) =2.22$, $p>0.05$ $\eta_p^2=0.003$, or interaction effect $F(1.76, 1194.4) = .429$, $p>.05$ $\eta_p^2=0.001$ did not reach significance, indicating that the scores were similar across groups.

We also further investigated this task in relation to our current measured forms of motivations and found that the current task was highly significantly correlated with autonomous motivation of participants across the 4 different timepoints: Baseline $r=0.095$ ($p<.05$), 1-month $r=.101$ ($p<.01$), 3-month $r=.122$ ($p<.01$), 6-month $r=.109$ ($p<.01$).

Innovative Single Category Implicit Association Test (SC-IAT)

Referring to the SC-IAT literature there was acceptable test-retest reliability of the app based SC-IAT (Lai & Wilson, 2021). We were able to observe highly significant inter-time point correlations (up to $r=.30$) in millisecond units.

We also conducted a 2x2 ANOVA to investigate any treatment v. control group differences across time. The main effect of time $F(2.45, 1659.45) = .354$, $p>.05$, $\eta_p^2=0.001$, did not reach significance, however we observed a significant group $F(1,677)=4.363$,$p<0.05$, $\eta_p^2>0.006$ and interaction effect of time and group $F(2.451,1659.45) = 4.631$, $p<.05$, $\eta_p^2=0.005$. When looking at post hoc analysis, a significant group different was observed at 3-months ($t(677)=-2.59$, $p<0.05$) and 6-months ($t(677)=-3.03$, $p<0.05$). This implies that the difference between groups can be observed at a minimum of 3-months of educational materials exposure. Looking at the means, the treatment group had slightly more negative implicit attitudes of doping than the control group.

Other than investigating the group and time effect, the results of the SC-IAT was also able to correlate significantly with our aforementioned canned beverage sorting task at all time points: Baseline $r=-0.10$, $p<.01$, 1-month $r=-0.11$, $p<.01$, 3-months $r=-0.10$, $p<.05$, 6-months $r=-0.09$, $p<.05$, showing an association between these two tasks. The negative direction of these associations also suggest that those who have strong negative implicit doping attitudes are more likely to inspect and accurately determine whether the ingredients list contained banned substances in our canned beverage task.

Discussion

Through phase 1, we were successfully able to develop a smartphone application that with a foundation of research findings, educational materials and assessment tools about psychological factors. In phase 2, we were also able to successfully test the effectiveness of the smartphone application via a randomised controlled trial in three countries.

Summary Overall Findings

In general, our results provided mixed findings where some variables were significant whilst others were not. We used a 2x2 ANOVA to analyse all the variables: Behavioural adherence to the avoidance of unintentional doping, motivation (autonomous, control and amotivation), self-control, canned beverage sorting game and the SC-IAT.

Variables that had a significant *interaction effect* were: self-control and the SC-IAT. A significant interaction effect means that there are differences across groups (treatment v. control) across time of which may be explained by the treatment effect. By the end of the experiment, we observed that those in the treatment group had lower self-control (due to stronger depletion of checking for banned substances; Tangney et al., 2004) and more negative implicit attitudes towards doping than compared to those in the control group.
We also observed that some variables revealed significant main effect of time, namely behavioural adherence to the avoidance of unintentional doping, self-control and canned beverage sorting game. The significant main effect of time in our current study signifies that all groups (treatment and control) had greater behavioural adherence to the avoidance of unintentional doping, self-control and checking of the ingredients list as our study progressed. One explanation of this is the mere measurement effect. As this study is longitudinal and that participants were consistently asked about doping, it is plausible that participants were able to guess the nature of the study and the study variables. Hence, over time, report greater behavioural adherence, self-control as well as check more carefully the ingredients list.

We also observed that the SC-IAT task revealed a significant main effect of group, suggesting that the treatment and control group had significant differences. Further analysis of this revealed that there was only a significant group difference at the 3-month and 6-month time point, suggesting that the treatment effect is observed at a minimum of 3-months.

Other than our study's main findings, our current study also successfully developed and tested a canned beverage sorting game. It is established that the consumption of unfamiliar substances may result in unintentional doping, and athletes who do not check the ingredients list of these prior to consumption may have heightened risk of such.

In light of such, our newly developed canned beverage sorting task was able to look into athletes awareness of unintentional doping. This task was not only able to mimic daily life by using canned beverage images, but it also tested (1) whether athletes check the ingredients list, and (2) test whether athletes were able to accurately determine whether it can be consumed or not. To this end, our results also revealed that autonomously motivated athletes (doing something because it aligns with their own goals) are associated with the number of correct responses in the canned beverage sorting task.

Another task that we incorporated and tested within the application was the upgraded version of the SC-IAT. Existing websites that measure SC-IAT traditionally contain 4 blocks and require the assistance of an external website (Greenwald et al., 2003). In our current application, we not only embedded this task inside the application, but we used 2 blocks instead. The use of 2 blocks within the context of doping has previously been done in paper versions of the SC-IAT. In our current study, we utilized their published protocol (Chan et al., 2018, Chan et al. ,2017; Lemm et al., 2008), and further tested it in an upgraded version of the SC-IAT. In doing so, we were still capable in calculating a D-score (the traditional outcome measure of an SC-IAT), and at the same time, minimize strain and inconvenience on our participants.

Our subsequent result of the SC-IAT also proved for it to be a promising tool in preventing unintentional doping. We were able to observe group differences (treatment v. control) and the treatment effect (interaction effect)_in our study, showing that those who were exposed to our educational materials held stronger negative implicit attitudes of doping compared to those in the control group. We were also able to significantly correlate our SC-IAT results with our canned beverage sorting task, associating negative implicit attitude of doping with checking the ingredients list for banned substances.

In our initial results, we have found that the canned beverage sorting task as well as the SC-IAT are a promising tool as both were tested and sought to provide good reliability and correlate well with our existing measures. Moreover, these two new tasks can serve as a foundation to incorporate objective measurements in the context of unintentional doping as compared to traditional self-reported methods.

Given a brief summary of our overall findings, the following discussion will look at our analysed results for each psychological variable in detail and draw in relevant theoretical support as well as draw attention to any limitations and further directions.

Behavioural Adherence to the Avoidance of Unintentional Doping

Within our study, we did not observe any (treatment v. control) group differences in the behavioural adherence to the avoidance of unintentional doping. With that said, there was however a significant difference in each observed timepoint (as denoted by our 2x2 ANOVA). Moreover, through further investigation of this, our results suggested that all participants, showed increases of behavioural adherence to the avoidance of unintentional doping as time passed.

This is unexpected compared to our aim as we hypothesized the treatment group to conduct greater behavioural adherence to the avoidance of unintentional doping only. However, in our case, both groups conducted greater behavioural adherence.

One explanation of this main effect of time is the mere measurement effect. The mere measurement effect suggests that participants know they are being monitored, hence they have increased awareness and may subsequently report socially desirable behaviours.

Psychological variables: Motivation

Our educational information were based off the theoretical framework of the self-determination theory, however our results were not able to observe any significant increase in autonomous, controlled or amotivation.

Given this, our results was unexpected. One explanation of this could be explained by the amount of exposure the athletes had with the educational information. In the current study, we provided the treatment group athletes with education information from a theoretically developed website. However the amount of exposure (i.e. the act of clicking into the educational materials) was entirely up to the participants, and we did not collect data in terms of their duration/how many

times they clicked to view the educational materials. Hence, this could be a limiting factor that may explain the lack of disparity between groups.

Although we were not able to observe any trends in the three motivation across groups and across time, we were still able to utilize participant's motivation data and correlate it with our two new innovative task. Moreover, our canned beverage sorting game was highly correlated with participants autonomous motivation. This is in line with the theoretical framework and previous studies, suggesting that participants autonomous motivation (motivation that aligns with their life-goals) are more likely to check the ingredients list by themselves (Chan et al., 2017, Chan et al., 2018; Deci & Ryan, 2008). Autonomous motivation in general, is the preferred type of motivation as compared to controlled motivation and amotivation as they do not require the presence of an external controlling contingency. With this, controlled motivated individuals, athletes may check the ingredients list only when their coaches are present, however autonomously motivated individuals, on the other hand will check the ingredients list regardless of whether their coach is present or not. Future direction for other studies can perhaps also investigate whether doing the canned beverage sorting task in front of their coaches/significant others will associate with their controlled motivation.

Psychological Variables: Self-Control

Other than forms of motivation, our current study also measured self-control. Within the Strength-energy model, it is theorised that self-control is a reservoir of psychological resources, moreover, those who engage in self-control (in this case, those who actively seek to avoid doping substances) are more likely to be depleted of self-control over time.

In our study, we were able to observe this phenomenon as our treatment group showed a significantly greater decline in self-control resources than those in the control group. This can be explained as the behavioural prevention of unintended doping (i.e. checking ingredients lists before consumption or not consuming any unfamiliar substances) requires a greater amount of self-control resources than those who do not prevent unintended doping. These subsequent self-control resources were then be observed to be depleted over time in our treatment group.

Given this, future initiatives could possibly look at lowering the amount of self-control needed to conduct behaviours to avoid unintentional doping as participants in the treatment group were more prone to exhaustion (depleted completely).

Innovative Canned Beverage Sorting Game

The canned beverage sorting game was designed to mimic a real-life scenario, whereby participants, when presented with an unfamiliar canned beverage, will choose either to drink or not to drink.

Our results were not only able to illustrate the significant effect of time, but our canned-beverage task was also able to highly and significantly correlated with participant's autonomous motivation. With this, our results are in line with the self-determination theory, which suggests that those with high autonomous motivation (i.e. avoiding unintentional doping because it is consistent with their life goals, personal values and responsibilities) are more able to accurately indicate the presence

of a banned substance when presented with an unfamiliar drink, ultimately avoiding unintentional doping.

With these initial results, this sorting paradigm can serve as a promising tool in doping research as it has not only shown to be reliable, but also has an association with a person's autonomous motivation, which is an important predictor. Further research can then aim to utilize this tool to explore its validity and potential of mimicking real-life scenarios.

Innovative Single Category Implicit Association Test (SC-IAT)

Through the SC-IAT our results indicated that athletes in the treatment group had stronger negative implicit attitudes towards doping. However, it is important to note that these implicit attitudes do not necessarily reflect their subsequent non-use/use of banned substances, but rather associate with their internal attitudes only of the concept of doping.

Our current study's SC-IAT descriptive results indicate that most participants have negative implicit attitudes towards doping (most scores and sample average were negative in nature).

Furthermore, as our treatment group have greater knowledge of what the performance enhancing drug can do and its banned sanctions (through the educational materials within the app), it can derive greater implicit dis-interest for the participants to dope, hence fostered greater negative implicit doping attitude.

Another part of our results found that our SC-IAT task correlated negatively with our canned beverage task. Our explanation of such association was that participants who were more implicitly negative towards unintentional doping were more likely to check the ingredients list and were more able to indicate any performance-enhancing substances in unfamiliar substances (significant positive correlation to canned beverage sorting task), ultimately choosing not to drink anything that contained banned substances.

Our current SC-IAT test within the app is still a newly developed tool, and already it has proved to provide promising results. Further studies can then utilize this observational tool and incorporate it when measuring implicit attitudes to unintentional doping.

Limitations

Given our comprehensive smartphone application, there are still areas of limitations. One limitation in the current study is whether the participants in the treatment group actually took the time to read, if not all, some of the anti-doping information provided in the application. The educational materials are the main variables manipulated in the current study, hence if the treatment group participants only had minimum exposure to the educational information, it may flatten the treatment effect.

Another limitation is the generalizability of the study. The current study was through a relatively controlled platform, whereby athletes in the treatment group were given these educational information. However in a real world setting, athletes in the normal population would have to

actively seek out accurate anti-doping information instead, hence may not necessarily reflect our study's findings.

Conclusion

A majority of the doping cases can be attributed to intentional doping, however there has been increasing incidences that doping occurred unintentionally or inadvertently. With this, new research is still needed to investigate psychological factors that are related to the prevention of unintentional doping. Through our successful development of a smartphone application, we were able to scratch the surface of such, paving the way for future research as we also introduced a total of 2 new assessments of unintentional doping.

In our study, we were able to include participants of different age, educational backgrounds as well as sporting backgrounds. These participants were then randomly assigned into a treatment condition or a control condition. The only difference of these two conditions was that the treatment condition participants had access to anti-doping information within the app. Through initial assessment and the subsequent three time point follow ups, we were then able to observe a number of differences when comparing our control v. treatment group. We found that at 3 months our treatment group had greater negative implicit doping attitude, put significantly more effort, and engaged more frequently in behaviours relating to unintentional doping than our control group. More interestingly, this trend can also be significantly observed at our 6-month follow up, suggesting that it is possible to be maintained if there was a longer follow up assessment.

In terms of psychological components, there was an interaction effect observed with the trait-self-control scale, indicating that, over time, the treatment group found maintaining behaviours relating to unintentional doping more effortful than our control group.

Lastly, within this application, we introduced two new innovative tasks: Beverage sorting task and the SC-IAT. The results of the beverage sorting task not only provided excellent test-retest reliability, but did also correlate significantly with autonomous motivation. The SC-IAT also correlated significantly with the beverage sorting task. With this, these two new innovative tasks are at a great advantage, giving new insight into objective assessments of participant's awareness to unintentional doping rather than self-reported or questionnaire assessments. Future research can therefore utilize these tests and aim to test the validity and applicability in mimicking a real-life-situation.

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