REDUCING DIABETES RISK USING Shae

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PRECISION INTELLIGENCE

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Being among one of the world's most prevalent non-communicable diseases, diabetes is currently affecting nearly half a billion people worldwide[1]. Despite imposing a heavy economic burden on public health, the prevention of the most prevalent type of diabetes, type 2, remains greatly underfunded[1] and yet remains a crucial step in providing advances for this group. Nonetheless, efforts must continue to help health-care providers and policy-makers improve the quality of care of diabetes patients through prevention and management research.

Fortunately, diabetes type 2 is, to a large extent, modifiable through lifestyle changes like diet and physical exercise that have been shown to successfully diminish its risk[2-4]. However, there are many barriers to lifestyle changes amongst individuals diagnosed with diabetes, including motivation and the effects of comorbidities[5], as well as difficulty adhering to programs for the long-term[6]. Even so, studies have shown that education and personalized information[7-9], self-monitoring[10-12], prompting healthy behaviors through mobile technology[13-15], and social support[16-18] are some of the key strategies that promote adherence to a healthier lifestyle[19-22]. Considering the lack of funding and the expense of in-person programs, mobile technology provides a promising means for this population and those at risk to gain access to these key factors for successful lifestyle changes[23,24].

The evidence-based Shae precision health and wellness program aims to support adopting healthier lifestyles, through personalized dietary recommendations, sleep cycle management, tailored exercise suggestions, and online social support[86,87]. It is available as an online app via desktop or mobile device with the possibility of receiving online community support from other participants. More details on the program's development, methodology, and aims can be found at https://shae.ai. Clinical data and ongoing survey data from the program have already suggested promising improvements in participants' lifestyle and current health, and thus warranted more robust statistical analyses. This study therefore used biometric measures and the Australian Type 2 Diabetes Risk (AUSDRISK) Assessment Tool[25] to assess the effects of the Shae precision health and wellness program on the participants' risk of developing type 2 diabetes within the next five years.

Methods

Data used for this study was collected from anyone who participated in the Shae precision health and wellness program over a four year period from 2014 to 2018 and agreed to have their data used for research purposes. Data consisted of age, gender, anthropometric measurements and survey responses.

Outcome measures

At each data point, the following anthropometric measures were collected: height, weight, neck circumference, waist circumference and hip circumference. Users were allowed to provide their measurements in US imperial (feet, inches, pounds), these were then converted into metric (centimeters and kilograms) in the database. Also, a survey was completed at each interval, in which participants provided information about their health behaviors (physical exercise, diet, smoking habits), as well as medical conditions. Using the user-provided data, body mass index (BMI), body fat index (BFI) and weight-to-height ratio (WHtR) were calculated, as well as AUSDRISK scores indicating risk for developing diabetes in the next five years.

These were calculated as follows:

- WHtR[26] = Waist / Height
- BMI[27-29] = Weight / (Height/100)2
- BFI[30] for men = 86.010 x log10 (Waist - Neck) - 70.041 x log10 (Height) + 36.76
  BFI for women = 163.205 x log10 (Waist + Hip + Neck) - 97.684 x log10 (Height) - 78.387
- AUSDRISK[25]: Depending on age, gender, ethnicity, medical history, anthropometric, and certain lifestyle behaviors, points are given and added up to provide an absolute total score, as per the AUSDRISK assessment tool[31].

Participants

To have the data included in the study, participants must have updated their data in a complete manner at regular intervals. Excluded were the data from participants who experienced a significant acute health event (eg: pregnancy, severe illness, hospitalization) or who did not provide sufficient data. After cleaning the data, a total 1,690 participants were included for analysis who provided a total of 5,220 completed assessments.

Table 1 shows the descriptive data of baseline anthropometric and medical measures, as well as lifestyle and exercise behavior when entering the study. The average age of participants was 51.2 (± 0.34) for female and 47.67 (± 1.02) for male participants, with 88.13% being of the female gender. 195 (13.3%) of female participants were diagnosed with diabetes, and 42 (18.8%) of male participants. Also, female participants had a slightly lower AUSDRISK scores (8.95 ± 0.12) compared to men (10.82 ± 0.33), and had less hypertension (11.4% of women versus 15.2% of men), but slightly more high cholesterol and hypoglycemia (both 3% of women versus 1.8% of men).

Table 1. Baseline characteristics of male and female participants.

	Female (n=1468)	Male (n = 222)
Sociodemographics – mean (SE)		
Age (years)	51.22 (0.34)	47.67 (1.02)
Lifestyle and exercise – mean (SE), N (%)		
Sedentary lifestyle	937 (63.8%)	103 (46%)
Little exercise	94 (6.4%)	4 (1.8%)
Moderate exercise	0 (0%)	0 (0%)
Intense exercise	0 (0%)	0 (0%)
Bodybuilding naturally	38 (2.6%)	1 (0.4%)
Bodybuilding with hormones	34 (2.3%)	7 (3.1%)
Smoking	29 (0.2%)	11 (4.9%)
Anthropometric measures – mean (SE)		
Body Mass Index	26.74 (0.15)	27.63 (0.32)
Body Fat Index	37.36 (0.26)	23.49 (0.48)
Waist	87.41 (0.35)	97.2 (0.91)
Weight	72.42 (0.43)	87.33 (1.1)
Height	164.41 (0.2)	177.61 (0.43)
Waist-to-Height-Ratio	0.58 (0.05)	0.55 (0.01)
Medical measures – mean (SE), N (%)		
AUSDRISK score	8.95 (0.12)	10.82 (0.33)
Hypertension	167 (11.4%)	34 (15.2%)
Diabetes	195 (13.3%)	42 (18.8%)
High cholesterol	24 (3%)	12 (1.8%)
Hypoglycemia	44 (3%)	4 (1.8%)

Statistical Procedures

Statistical tests to assess changes over time and differences between groups consisted of paired sample t-tests, and a linear mixed-effect regression model for each participant. After assessing descriptive changes in health behaviors, medical conditions, anthropometric measurements, and the AUSDRISK score, an in-depth analysis was done in order to assess possible significant changes in each of the measures assessed.

Results

Table 2 shows the participants' average anthropometric measures, AUSDRISK scores, medical conditions, and physical activity, when starting the program (aka: Baseline) as well as at the end of their participation (aka: Follow-up), stratified by male and female participants. On average, participants stayed in the program approximately 11 months. Although important decreases were seen in each of the participants' anthropometric measures, the decrease in WHtR appeared to be the most significant. For example, mean BMI and BFI decreased for both men and women, but while men's mean WHtR fell from 0.55 to 0.51, women's mean WHtR managed to fall below the recommended health cut-offs to 0.49 from 0.58.

Among the participants who declared being smokers at baseline, almost half (47.5%) had quit smoking after having followed the program. With regard to sedentary lifestyle, 12.7% of participants indicated being more active than when starting the program, increasing their activity levels to moderate (5-10 hours of exercise per week) or intense (>10 hours of exercise per week).

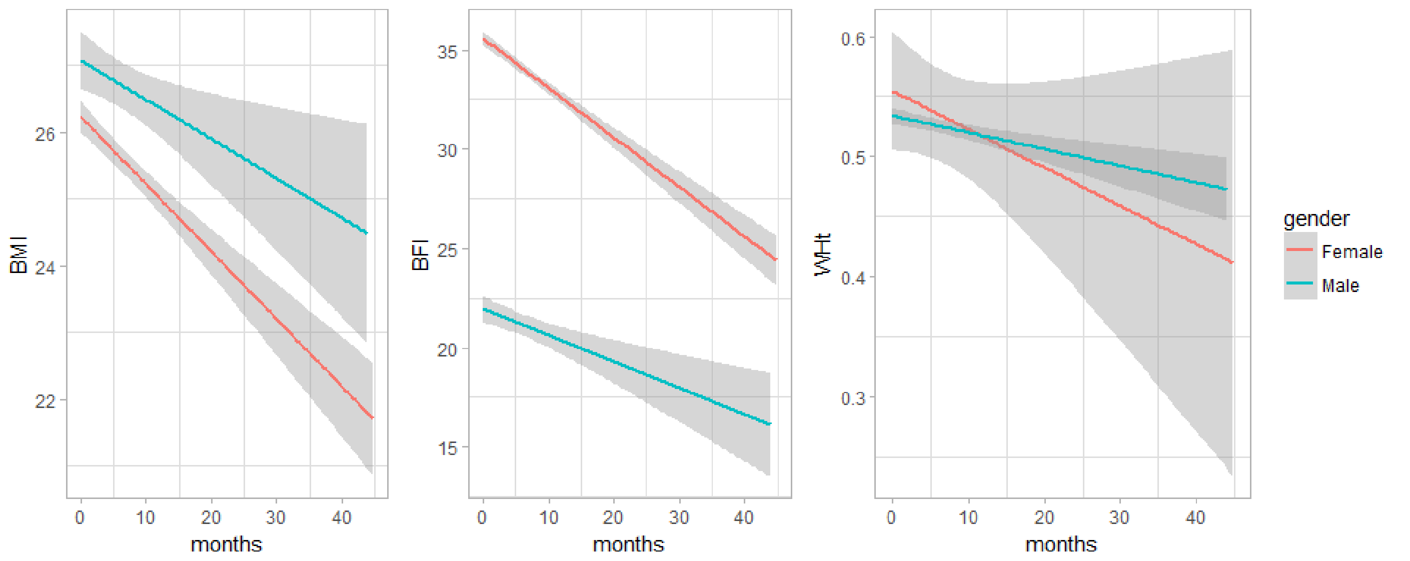
With regard to diabetes risk, AUSDRISK scores decreased for both genders, suggesting that the program has a beneficial effect on lowering their risk of developing diabetes in the next 5 years.
The correlated health factors also decreased for both genders. For example, there was a significant decrease in the number of participants suffering from medical conditions a 72.6% decrease in hypertension after having followed the program in participants who were initially diagnosed with hypertension. Similarly, there was a 79.2% decrease in participants reporting initial dysglycemia, and a 86.1% decrease in participants with initial high cholesterol.

Table 2. Baseline and follow-up characteristics of male and female participants.

	Female (n=1468)		Male (n = 222)	
	Baseline	**Follow-up**	**Baseline**	**Follow-up**
Age (years)	51.22 (0.34)	52.32 (0.34)	47.67 (1.02)	48.41 (0.99)
Lifestyle and exercise – mean (SE), N (%)				
Sedentary lifestyle	937 (63.8%)	916 (63.3%)	103 (46%)	110 (50.2%)
Little exercise	94 (6.4%)	145 (10%)	4 (1.8%)	9 (4.1%)
Moderate exercise	0 (0%)	12 (0.8%)	0 (0%)	5 (2.3%)
Intense exercise	0 (0%)	0 (0%)	0 (0%)	1 (0.5%)
Bodybuilding naturally	38 (2.6%)	37 (2.6%)	1 (0.4%)	2 (0.9%)
Bodybuilding with hormones	34 (2.3%)	35 (2.4%)	7 (3.1%)	7 (3.1%)
Smoking	29 (0.2%)	21 (1.5%)	11 (4.9%)	4 (1.8%)
Anthropometric measures – mean (SE)				
Body Mass Index	26.74 (0.15)	25.23 (0.14)	27.63 (0.32)	26.44 (0.3)
Body Fat Index	37.36 (0.26)	32.72 (0.24)	23.49 (0.48)	19.76 (0.46)
Waist	87.41 (0.35)	80.98 (0.31)	97.2 (0.91)	91.15 (0.82)
Weight	72.42 (0.43)	68.59 (0.4)	87.33 (1.1)	83.8 (1.06)
Height	164.41 (0.2)	164 (0.20)	177.61 (0.43)	177.84 (0.44)
Waist-to-Height-Ratio	0.58 (0.05)	0.49 (0.01)	0.55 (0.01)	0.51 (0.01)
Months in program	0 (0)	11.7 (0.25)	0 (0)	10.27 (0.62)
Medical measures – mean (SE), N (%)				
AUSDRISK score	8.95 (0.12)	7.87 (0.1)	10.82 (0.33)	9.79 (0.3)
Hypertension	167 (11.4%)	116 (8%)	34 (15.2%)	15 (6.85%)
Diabetes	195 (13.3%)	129 (8.9%)	42 (18.8%)	33 (15.1%
High cholesterol	24 (3%)	12 (1.5%)	12 (1.8%)	5 (1.4%)
Hypoglycemia	44 (3%)	22 (1.5%)	4 (1.8%)	3 (1.4%)

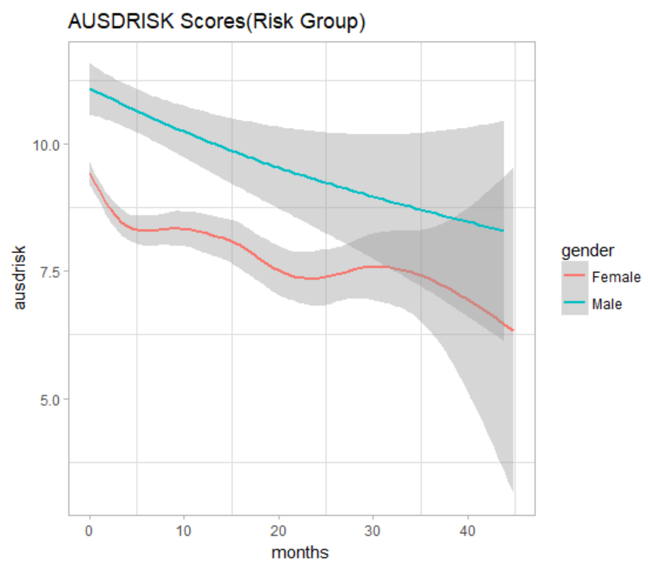
In order to assess the type of progression made in anthropometric measures during the program, another linear regression model was used. As discussed above, important reductions occurred in BMI, BFI, and WHtR, especially in women across all age groups ($p < 0.05$). The linear trend in Figure 1 shows the gradient of these reductions from baseline to follow-up, indicating a more rapid decreased in female participants compared to male participants.

Figure 1. Changes in BMI, BFI, and WHtR of male and female participants over time.



In relation to the AUSDRISK score (Figure 2), a significant decrease in diabetes risk of both men and women were observed (decrease of 0.91 points, $p < 0.005$). This decrease was greater among women of all ages (with changes of up to -4.23, $p < 0.01$) compared to the male participants (up to -2.63, $p < 0.1$). Compared to men, who experienced a steady but gradual reduction in diabetes risk, women experienced a more rapid but wavering reduction. Furthermore, the longer participants remained in the program, the greater their improvements were, with an average 0.0011 decrease in diabetes risk score for every additional day of participation ($p < 0.005$).

Figure 2. Changes in diabetes risk scores of male and female participants over time.



Conclusion

Results from this study provide strong evidence on the beneficial effects of using a mobile application to decrease diabetes risk in participants by encouraging them to adopt healthier lifestyle habits and maintain them for the long term. On average, participants stayed in the program approximately 11 months, which is a sufficient amount of time to make lasting changes in lifestyle habits[32-33]. The improvements in diabetes risk were due to several significant reductions in body fat index[34-36], body mass index[37-39], and waist-to-height-ratio[40-44], but are also partly reflected in the reduction found in several medical conditions, which are known to play important roles in the development of diabetes[45-48], as well as the significant increases in healthier lifestyle behaviors associated with decreased diabetes risk2,[49-52].

Overall health improvements and a reduction in diabetes risk were found across the board, with women between 40 and 70 years of age making the greatest improvements. Considering female participants[43,53-55] of a certain age are known to struggle more with losing weight and maintaining those results[56-60], this is a very encouraging finding. Also, the longer participants stayed in the program, the more there was a reduction in diabetes risk score. This is not surprising, as behavioral changes take time to form and implement habits[49], but it does underline the long term viability of the program. Another noteworthy finding is that participants with initial high risk for developing diabetes saw significant reductions after having followed the program, which is great since this subgroup likely has less healthy lifestyle behaviors than those at lower risk, thus might be less inclined to make long lasting changes to their behavior in favor of their health[61,62]. These results suggest that the program not only has a positive effect on lifestyle changes and body measurements, but may have an important beneficial effect on illnesses that are compromising to health and are often difficult to improve without proper medical treatment and guidance[63,64].

Though this study is limited by a rather small population size that is predominated by middle-aged women, and warrants being repeated in future studies, the voluntary inclusion of participants in the study may be representative of the target population of online health and wellness interventions. Furthermore, despite the encouraging results found in the subgroup analysis on higher risk participants, it would also be interesting to conduct further studies on such online programs targeted specifically towards at-risk populations. Nonetheless, this study shows promising results because of the use of various anthropometric measures simultaneously. For instance, the use of BMI may not be an accurate representation of fat mass and health status when used alone[65-67], but the combination of multiple measures may provide a suitable and practical alternative measures like the computed tomography[68-71], especially when conducting studies on a population with variable ethnicities and ages[72-78].

As demonstrated in numerous previous studies, successful prevention of diabetes is highly influenced by lifestyle-related interventions[51,52], such as adopting a healthier diet[50] and increasing physical exercise[79,80], which in turn result in weight and fat loss[50,81,82] and is reflected in improved anthropometric measures. This study provides the statistical evidence on the prior assumptions that participants of the Shae precision health and wellness program not only adopt healthier lifestyle behaviors and achieve better body measurements, but their risk of developing diabetes in the next five years consequently diminishes over the course of the program. The findings are supportive of the program's most important aim to support men and women of all ages in making healthier long term lifestyle changes, and improve their physical and mental quality of life[83-85].

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