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Relationships among changes in physical activity, quality of life, and obesity-Status following a behavioral intervention for rural Appalachian adults

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ABSTRACT

Improved health-related quality of life (HRQoL) is one benefit of physical activity. Yet, there is limited intervention research exploring (1) whether changes in physical activity influence changes in HRQoL among community-based populations and (2) if baseline obesity status influences the relationships. This exploratory analysis used secondary data from rural Appalachian adults who completed the MoveMore arm of a larger randomized control trial (n = 105, M_{age} = 41.8, 82 % female, 96 % White, M_{income}= $25,911). Specifically, this study examined associations among changes in physical activity and HRQOL and whether baseline obesity status moderated changes. Three HRQoL variables (self-rated health status, total unhealthy days, days poor health impacted activities) and two physical activity variables [weekly moderate-vigorous physical activity (MVPA) minutes, weekly strength training minutes] were collected at baseline and 6-months. Regression models, adjusted for age, gender, race, income, education, assessed associations between physical activity and HRQoL change variables. Moderation analyses explored the influence of baseline obesity status on these relationships. Participants reported significant improvements in self-rated health status (P = 0.001), weekly MVPA minutes (P = 0.008), and weekly strength training minutes (P < 0.001). Increasing weekly strength training minutes was associated with fewer days poor health impacted activities (B = -0.040, P = 0.013). Weekly minutes of MVPA was not associated with HRQoL variables. Baseline obesity status did not moderate relationships. Findings suggest increasing weekly strength training may reduce days poor health impacted activities and that relationships among changes in physical activity and HRQoL were not impacted by baseline obesity. Findings have implications for promoting strength activities in community-based physical activity interventions for rural populations.

1. Background

Engaging in physical activity is associated with reduced risk for preventable health conditions, such as obesity, diabetes, and heart disease (Reiner et al., 2013). Current guidelines to promote health and reduce chronic disease risk recommend that adults engage in 150 min of moderate to vigorous intensity cardiovascular activities and two days of strength training per week (U.S. Department of Health and Human Services, 2018). However, <30 % of the U.S. adult population meets recommendations (Centers for Disease Control and Prevention, 2018). Importantly, only 20 % of rural adults meet these physical activity guidelines (Whitfield et al., 2019), and rural communities experience higher obesity rates and other health disparities than other regions of the country (Garcia et al., 2017; Trivedi et al., 2015)..

Improved quality of life, (QoL) is one benefit of physical activity. QoL is a broad concept that encompasses physical, mental, financial, and social well-being (Karimi and Brazier, 2016; Sosnowski et al., 2017). Health-related quality of life (HRQoL) focuses specifically on aspects of QoL that are part of an individual's health (Karimi and Brazier, 2016; Sosnowski et al., 2017). An individual's HRQoL is impacted by numerous factors, including age, gender, race, income, education, and weight status (Carson et al., 2014; Goldenberg et al., 2014; Kolotkin and

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Andersen, 2017; Bize et al., 2007; Sach et al., 2007; Hassan et al., 2003). Rural adults are more likely to have lower HRQoL than those living in urban areas, with approximately 40 % of rural adults reporting excellent or very good health compared to 45 % of urban adults (Bethea et al., 2012). Furthermore, rural adults experience greater health disparities and social determinants associated with lower HRQoL than those in other regions (Garcia et al., 2017; Bethea et al., 2012; Rural Health Information Hub, 2021). Cross-sectional evidence strongly supports a positive relationship between physical activity and HRQoL across age, gender, and health conditions (Bize et al., 2007; Brown et al., 2014). Likewise, an inverse relationship between sedentary behavior and aspects of HRQoL has been identified (Saunders et al., 2020). Interventional studies demonstrate that physical activity interventions can increase QoL, generally, and HRQoL, specifically, with the majority of literature focused on older adults and/or adults with specific health conditions (e.g., diabetes, cardiovascular disease, inflammatory disease, cancer, mental illness) (Al-Ghafri et al., 2020; Broekhuizen et al., 2016; Imayama et al., 2011; Lidin et al., 2018; O'Dwyer et al., 2017; Robertson et al., 2019; Rogers et al., 2015; Rosenbaum et al., 2014). Yet, as these studies frequently report only pre-post changes, there is limited evidence of the relationship between *changes* in physical activity and *changes* in HRQoL due to participation in an intervention. Existing evidence that explores this relationship comes primarily from interventions for older adults and for adults with diagnosed health conditions (Broekhuizen et al., 2016; Robertson et al., 2019)..

Obesity status may influence the relationship between changes in physical activity and changes in HRQoL. However, existing evidence is conflicted as to whether obesity status would strengthen or weaken the relationship. Individuals who are obese report lower levels of HRQoL compared to those who are overweight or at a healthy weight (Sach et al., 2007; Hassan et al., 2003). Lower baseline values may allow for greater improvement during the intervention. Also, overweight and obese individuals who initiate new physical activity programs have demonstrated improvements in HRQoL (Heath and Brown, 2009). Conversely, qualitative evidence suggests that individuals who are obese may experience more consequences of engaging in physical activity (e.g., injury, negative emotions) that could negatively impact HRQoL (Toft and Uhrenfeldt, 2015).

Understanding the relationships among changes in physical activity and changes in HRQoL as well as the impact of obesity status on these relationships could better inform the development of physical activity interventions, which may be of particular importance for rural residents. Therefore, the purpose of this study was to describe changes in HRQoL among rural participants in a community-based physical activity intervention that was open to all adults (Move More) and assess whether changes in weekly minutes engaged in moderate-vigorous physical activity (MVPA) and in strength training are associated with changes in HRQoL. It also explored whether baseline obesity status moderates the relationships between changes in physical activity and HRQoL.

2. Methods

This study is a secondary analysis of data from the MoveMore arm of the Talking Health trial (Zoellner et al., 2014, 2016). MoveMore is a community-based intervention shown to improve physical activity behaviors among adults living in rural Appalachian communities in Virginia (Zoellner et al., 2014, 2016). These communities, which are predominantly White and geographically isolated, experience disparities related to socio-economic status, education, access to health care, and rates of chronic disease (Estabrooks et al., 2011). During this trial, participants were randomized into either MoveMore or a matched contact intervention targeting sugar-sweetened beverage behaviors, SIP*smart*ER. Study procedures were approved by the Virginia Tech Institutional Review Board. Participants provided written informed consent and received $25 and $50 in gift cards for completing baseline and 6-month health screenings.

2.1. MoveMore intervention

The six-month MoveMore intervention was designed to increase participants' level of physical activity, with a target to achieve the weekly recommendations: 150 min of MVPA and two days of muscle-strengthening activities (U.S. Department of Health and Human Services, 2018). MoveMore was adapted from an effective group-based physical activity program by behavioral scientists with expertise in physical activity (Pollard and Jacobsen, 2019) to allow it to better meet the needs of adults living in rural southwest Virginia. The program was delivered by Masters and PhD-level health educators and consisted of three in-person classes, one teach-back call, and 11 interactive voice response calls. Through these components, participants developed knowledge and skills related to physical activity, set personalized action plans to increase MVPA and strength training, and received feedback on their goal achievement. Components are described in detail elsewhere (Zoellner et al., 2014, 2016).

2.2. Recruitment

Participants were recruited from four health districts in rural Appalachian Virginia with documented health disparities (Estabrooks et al., 2011). Interested individuals were screened using the following criteria: age $\geq$ 18 years, English speaking, consuming $\geq$ 200 calories per day from sugar sweetened beverages, no contraindications to physical activity (as assessed by the adapted Physical Activity Readiness Questionnaire (Thomas et al., 1992), and telephone access. Weight status was not an inclusion criterion. Though not an exclusion criterion for participation in the intervention, pregnant participants were excluded from this secondary analysis due to the impact of pregnancy on weight and HRQoL (Lagadec et al., 2018).

2.3. Data collection and measures

This study used HRQoL, physical activity, weight, and demographic data. Data were collected during the recruitment process as well as baseline and 6-month health screenings.

2.3.1. Health-Related quality of life

Participant HRQoL was collected at the baseline and six-month health screenings using the validated "Healthy Days Core Module." (Moriarty et al., 2003; Slabaugh et al., 2017; Barile et al., 2013). Participants answered four questions based on their experiences over the past month: (i) self-rated health status, (ii) days of poor physical health, (iii) days of poor mental health, and (iv) days that poor physical or mental health impacted usual activities (days poor health impacted activities). Self-rated health status was scored on a five-point scale: 0 (excellent) to 4 (poor). For the other variables, participants entered a continuous number of days from 0 to 30. Following standard scoring procedures, "days of poor physical health" and "days of poor mental health," were summed to create a total number of unhealthy days variable and truncated at 30 (Moriarty et al., 2003).

2.3.2. Physical activity

We measured participant physical activity behaviors at baseline and six-month health assessments using a modified version of the validated Godin Leisure Time Exercise Questionnaire (Godin, 1997). This modified version, which allows for the calculation of the minutes per week of mild, moderate, and vigorous physical activity, is frequently used (Amireault and Godin, 2015). During an interview-administered survey by a trained research assistant, participants identified the number of times they engaged in mild aerobic activity, moderate aerobic activity, vigorous aerobic activity, and strength training for more than 15 min over the past week. Participants also identified the average time they spent in each activity. Using the modified scoring procedure, we then calculated weekly minutes of MVPA and strength training. Weekly

minutes of MVPA were calculated for both time points by multiplying the number of times moderate and vigorous physical activity activities were reported with the average length of each activity and then adding the two products together. Baseline and 6-month minutes of strength training were calculated by multiplying the number of times strength training was reported with the average number of minutes for strength training activities (Zoellner et al., 2016).

2.3.3. Weight and height

Participant weight and height were collected at the baseline health screenings, which occurred in the morning. Participants were asked to fast overnight before their appointment. Weight was measured using a calibrated digital Tanita scale (Model: SC-331S). Participants removed shoes, outer clothing (e.g., sweatshirts), belts, and items from their pockets prior to stepping onto the scale. Weight was recorded in kilograms. Participant height, without shoes, was measured using a research grade stadiometer (Seca 213 Portable Stadiometer). We calculated baseline BMI following standardized procedures and categorized BMI scores into obese (BMI $\geq$ 30) and not obese (BMI $<$ 30). This cut-off reflects literature that suggests higher weight/BMI is associated with poorer HRQoL and that reported HRQoL for overweight individuals does not differ from normal or under- weight adults (Sach et al., 2007; Hassan et al., 2003).

2.3.4. Demographics

We also collected data related to five demographic variables that have been associated with HRQoL outcomes in previous studies (Kolotkin and Andersen, 2017; Bize et al., 2007). All were collected during screening: (1) *age:* continuous variable, (2) *gender*: male or female; (3) *race*: six categories based on the NIH protocol; (4) *highest level of educational attainment*: six categories from completed Grade 8 to graduate school; and (5) *household income*: twelve categories ranging in $5,000 segments from less than $5,000 to $50,000/year or more.

2.4. Analysis

Data analysis was conducted using Stata version 16 (StataCorp LCC, 2019). Of the 146 participants randomized into MoveMore at baseline, the 105 participants who completed both baseline and six-month health assessments and had complete data were included in this secondary analysis. A completers analysis was used as the study's small sample size and the limited variations of the HRQoL variables would cause concerns for the validity of HRQoL outcome imputations. Importantly, there were no significant differences in baseline HRQoL variable scores between completers and non-completers.

Three HRQoL change variables were created by subtracting six-month score from baseline score: (i) change in self-rated health status, (ii) change in total unhealthy days, and (iii) change in days poor health impacted activities. We also created two physical activity change variables: change in weekly minutes of MVPA and change in weekly minutes of strength training by subtracting baseline responses from six-month responses.

Demographic variables were recoded for analytical purposes. Race was collapsed into two categories: White and people of Color. Household income was transformed into a continuous variable. Each income category was assigned a numeric value equal to the average of its lowest and highest values (e.g., $10,000 - $14,999 became $12,250).

2.4.1. Statistical approach

We used descriptive statistics (frequencies, means and standard deviations) to describe the study sample as well as HRQoL and physical activity variables. Paired t-tests were used to compare average levels of HRQoL and physical activity between baseline and 6-month.

To assess associations among changes in physical activity and changes in HRQoL, we conducted mixed effect regression analyses for each of the three HRQoL change constructs. The models included physical activity change variables with demographic variables as control variables [age (continuous variable), gender (dummy coded male = 0, female = 1), race (dummy coded people of Color = 0, White = 1), income (rank variable), and education (rank variable)]. These control variables have been associated with HRQoL outcomes in previous studies (Kolotkin and Andersen, 2017; Bize et al., 2007). To determine whether baseline obesity status (obese versus non-obese) influenced the relationship between change in physical activity and change in HRQoL, we conducted moderation analyses under the similar mixed effect model specification as above with the addition of full interaction between baseline obesity status and physical activity change variables. All mixed effect models computed cluster robust standard errors to recognize the cohort nesting nature of our data. Shapiro-Wilks W tests p values for the models were greater than 0.05 and fail to reject normality.

3. Results

3.1. Participants

Participants (n = 105) were on average 41.8 (SD = 13.1) years old, female (82 %), White (96 %), and had attended at least some college (73 %). Forty-eight percent (n = 50) of participants made less than $20,000 per year. At baseline, the average weight of participants was 91.5 kg (SD = 25.0) and 58 % (n = 61) were obese, 21 % (n = 22) were overweight, 20 % (n = 21) were normal weight, and 1 % (n = 1) were underweight. Participants reported an average self-rated health status score of 2.2 (SD = 0.96), with 19 % reporting excellent or very good health. Also, participants reported 6.84 (SD = 6.97) total unhealthy days and 2.23 (SD = 3.50) days poor health impacted activities. Average baseline physical activity was 73.8 (SD = 126.2) minutes of MVPA per week and 9.6 (SD = 32.7) minutes of strength training per week.

3.2. Change in HRQoL and PA variables

Table 1 illustrates significant improvements in self-rated health status ($P < 0.001$), weekly MVPA minutes (~54 more minutes per week, $P = 0.008$), and weekly strength training minutes (~22 more minutes per week, $P < 0.001$). At baseline, 19 %, 10 %, and 4 % of participants met U.S. recommendations for aerobic physical activity, strength training, and both aerobic physical activity and strength training, whereas at six-month, 31 %, 33 %, and 19 % met these respective

Table 1
Baseline and 6-month Means (SD) for Physical Activity and Health-Related Quality of Life Variables.

	n	Baseline	6-month	Change	Statistic (p-value)
Health-Related Quality of Life					
Self-rated health status[a]	104	2.20 (0.96)	1.95 (0.93)	−0.25 (0.73)	**3.473 (0.001)**
Total unhealthy days[b]	105	6.84 (6.97)	6.70 (6.54)	−0.14 (8.78)	0.167 (0.868)
Days poor health impacted activities[b]	105	2.23 (3.50)	2.81 (4.40)	0.58 (5.23)	−1.139 (0.257)
Physical Activity					
Weekly minutes of moderate/ vigorous physical activity	105	73.8 (126.18)	127.4 (184.22)	53.6 (204.61)	**−2.684 (0.008)**
Weekly minutes of strength training	105	9.57 (32.69)	31.4 (62.42)	21.8 (56.04)	**−3.993 (<0.001)**

[a] Item is score 0 = Excellent 1 = very good, 2 = good, 3 = fair, and 4 = poor
[b] Potential range of scores is 0 – 30

recommendations (data not in table).

3.3. Relationship between change in PA and change in HRQoL variables and moderation by baseline obesity status

Regression results are presented in Table 2. Neither change in self-rated health status nor change in total unhealthy days were statistically significantly impacted by change in weekly MVPA minutes or change in weekly strength training minutes. Change in days poor health impacted activities was statistically significantly influenced by change in weekly strength training minutes (β=-0.019, $P = 0.004$), but not by change in weekly MVPA minutes. While controlling for change in weekly MVPA minutes along with other control variables, each additional minute of increase in strength training per week was associated with approximately 0.02 fewer days (29 min) per week impacted by poor health.

As further illustrated in Table 2, obesity status did not significantly moderate the relationship between change in physical activity variables and any of the three HRQoL change variables. Yet, the moderation analysis reveals that changes in total unhealthy days were significantly influenced by change in strength training minutes (β=−0.040, $P = 0.004$); however, the improvement is not significantly different by obesity status. While controlling for change in weekly MVPA minutes and other controls, each additional minute strength training per week was associated with approximately 0.04 fewer days (58 min) per week impacted by poor health for those who were not obese at baseline.

4. Discussion

Findings from this study add to the body of literature related to the relationship among physical activity and HR-QoL. Specifically, the major takeaways are that increasing weekly minutes of strength training was associated with fewer days of poor health impacted activities and that baseline obesity status did not moderate relationships among included physical activity and HRQoL variables.

This study explored the relationship between physical activity and HRQoL differently from previous studies. First, most prior studies assessing this relationship used cross-sectional data (Bize et al., 2007; Brown et al., 2014) and could not determine whether physical activity changes facilitates HRQoL changes. Our study used pre-post data from a behavioral intervention and was able to assess the relationship between the changes in these variables. Second, the majority of previous physical activity intervention studies that have examined this relationship have targeted specific populations, such as the elderly, those with chronic diseases, and cancer survivors (Al-Ghafri et al., 2020; Broekhuizen et al., 2016; Imayama et al., 2011; Lidin et al., 2018; O'Dwyer et al., 2017; Robertson et al., 2019; Rogers et al., 2015; Rosenbaum et al., 2014). However, this study's findings reflect a relatively broader population cross-section, as, while pregnant women were excluded from the analysis, enrollment into MoveMore was not limited by age, health condition, or weight.

Our study is also distinct from prior literature in that the regression models included changes in weekly strength training. Of the two known studies that have looked at the relationship between change in PA and change in HRQoL following a physical activity intervention, both only measured the relationship between change in MVPA and change in HRQoL indicators (Broekhuizen et al., 2016; Robertson et al., 2019). A key takeaway from our study is that increasing strength training may improve aspects of HRQoL. Specifically, each additional minute engaged in strength training per week was associated with approximately 0.02 fewer days (29 min) per week in which activities were impacted by poor health. To put this into perspective, the average MoveMore participant, who increased weekly strength training minutes by 22 min, would have 10.6 fewer hours per week where their activities were impacted by poor health. These interpretations help inform the clinical significance of these statistically significant findings. Additionally, the moderation analysis identified a relationship between number of unhealthy days and weekly minutes of strength training. However, the baseline weight status did not moderate the relationship. In this model, each additional minute engaged in strength training per week was associated with approximately 0.04 fewer unhealthy days, or one fewer unhealthy days for 25 additional minutes of strength training per week. Therefore, this finding provides support for stressing weekly strength training in physical activity interventions, which is also important given that 72 % of U.S. adults do not meet strength training recommendations (Centers for Disease Control and Prevention, 2018).

To our knowledge, no other studies have looked at how baseline obesity status may impact the relationship between changes in physical activity and changes in HRQoL. Understanding this relationship is important as there is conflicting evidence that baseline obesity has the potential to either strengthen or weaken this relationship (Sach et al., 2007; Hassan et al., 2003; Toft and Uhrenfeldt, 2015; Hageman et al., 2019). Though the statistical power for this analysis was limited, our exploratory finding suggests that weight status does not moderate the relationship between changes in physical activity and HRQoL. This lack of moderation could reflect the complex benefits and encumbrances that increased physical activity has on HRQoL among individuals with obesity (Toft and Uhrenfeldt, 2015). This highlights the importance of designing and implementing physical activity interventions that may improve the HRQoL of all individuals, regardless of weight status, especially in rural areas that have high rates of inactivity (Centers for Disease Control and Prevention, 2018) and lower rates of HRQoL than

Table 2
Regression Models Assessing Relationships among Changes in Physical Activity and Changes in Health-Related Quality of Life, and Moderation by Baseline Obesity Status.

	Change in Self-Rated Health Status (n = 104)[a,b]		**Change in Total Unhealthy Days (n = 105)[b]**		**Change in Days Poor Health Impacted Activities (n = 105)[b]**	
	Regression Model	Regression Model with Moderation	Regression Model	Regression Model with Moderation	Regression Model	Regression Model with Moderation
	B (SE)	B (SE)	B (SE)	B (SE)	B (SE)	B (SE)
Change weekly MVPA (minutes)	−0.001 (0.001)	−0.000 (0.000)	−0.000 (0.004)	0.001 (0.003)	0.003 (0.002)	−0.000 (0.002)
Change weekly strength training (minutes)	0.000 (0.002)	−0.001 (0.001)	−0.021 (0.023)	**−0.040** (0.013)**	**−0.019*** (0.004)**	−0.013 (0.004)
Obese at baseline * change weekly MVPA minutes		−0.001 (0.001)		−0.001 (0.009)		0.006 (0.005)
Obese at baseline * Change weekly strength training minutes		0.002 (0.005)		−0.079 (0.043)		−0.010 (0.008)

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$
[a] Missing data for one participant
[b] Age, sex, race (White, people of Color), income, and education were controlled for in all models;

other regions (Bethea et al., 2012).

Similar to previous studies, this study's results indicate a lack of consistency regarding which aspects of QoL, or specifically HRQoL, are impacted by change in physical activity. Robertson and colleagues found that, among endometrial cancer survivors who completed a phone-based physical activity intervention, increased MVPA was associated with a desirable changed perceptions of physical role limitation, pain, and general health but not other aspects of QoL, such as mental health, social and emotional functioning (Robertson et al., 2019). Broekhuizen and colleagues found, that following an internet-based intervention for inactive older adults, increased daily minutes of MVPA was associated with desirable changes in emotional/mental health, perceptions of role limitations due to mental health, and general health perception but not other aspects including pain, vitality, role limitation, and physical functioning (Broekhuizen et al., 2016). Taken together, findings from these previous studies and our current one underscore suggest that the relationship between changes in physical activity and changes in HRQoL is complex. This suggests that future researchers should be thoughtful when designing, powering, and selecting measures to assess change in HRQoL in their interventions.

Additionally, study findings suggest MoveMore participants improved one indicator of HRQoL, their self-rated health status. Importantly, study participants reported lower HRQoL than has been reported in a national sample of rural adults (Bethea et al., 2012). This evidence suggests the MoveMore intervention may have important health benefits for participants beyond increasing weekly minutes of MVPA and strength training, as previously identified (Zoellner et al., 2016).

There are a few limitations to the present study. First, as a secondary analysis, power for the moderation analysis was limited by sample size. Second, the generalizability of the findings is limited due to the predominantly White, middle-aged, and female sample. However, the sample was racially representative of the targeted region and reflects a rural and relatively low-income population that experiences greater health disparities relative to other populations (Estabrooks et al., 2011). Third, due to the small sample size and limited variations in our data, our results are not generalizable to those non-completers. Fourth, the physical activity measure relied on participant self-report. These limitations should be considered within the strengths of this study. Notably, data were from an intervention study of a physical activity intervention that was found to be effective at improving weekly minutes of both MVPA and strength training among participants of different weight statuses (Zoellner et al., 2016).

There are several considerations for future research related to the relationship between change in PA and change in HRQoL. First, future physical activity interventions should measure and report on HRQoL. Second, future studies should incorporate more comprehensive QoL measures, such as the World Health Organization Quality of Life Assessment and the Medical Outcomes Study Short Form Instruments (e.g., SF-36, SF-12), (Pequeno et al., 2020) to allow for distinct aspects of HRQoL to be assessed individually (e.g., exploring physical and mental health aspects of HRQoL separately) and to identify the clinical significance of the findings. Third, studies with larger and more diverse sample sizes are needed to better understand relationships between change in physical activity and change in HRQoL, as well as how different categories of weight status (i.e., normal, overweight, obese, severely obese) moderate these relationships. Fourth, studies should explore between changes in HRQoL and changes in both MVPA and strength training.

Additionally, there are implications for practice. Notably, findings suggest that community-based physical activity interventions should target increasing weekly strength training minutes in addition to increasing weekly minutes of MVPA. Also, they suggest that all community members should be eligible to enroll in these interventions, regardless of obesity status.

Overall, study findings contribute to the larger literature base, including suggesting that increasing strength training is associated with reduced days where activities are impacted by poor health and that obese status at baseline does not moderate the relationship between changes in physical activity and HRQoL.

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Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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