

Belief drives physiology: A wearable device expectancy study in healthy young adults

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Abstract

Wearable devices are widely used in health and performance settings, yet it is unclear whether belief in a device can influence physiological or performance outcomes independent of its function. Expectancy effects have been documented in sport and exercise contexts, but findings on objective strength outcomes are mixed. This study tested whether the presence of an inactive smart ring, with or without an expectancy-oriented script, was associated with changes in maximal strength or cardiovascular arousal during acute assessment. Twenty healthy adults completed a randomized, placebo-controlled, within-subject crossover trial with three conditions: control (no device), ring-only (inactive smart ring), and ring-plus-script (inactive ring paired with a standardized expectancy statement). Handgrip strength and resting heart rate (HR) were recorded under standardized conditions. Strength did not differ across conditions ($p = 0.21$), indicating that a single expectancy exposure did not increase maximal voluntary force production. HR differed significantly across conditions in the subset of participants with complete HR data ($n = 14$; $p < 0.001$), with higher HRs observed in both the ring-only ($p = 0.005$) and ring-plus-script ($p = 0.006$) conditions compared with control, and no difference between the two ring conditions. The overall effect was large and observed in fourteen participants with complete HR data. These findings suggest that expectancy associated with a wearable device can influence cardiovascular arousal during early exposure, while not improving maximal strength. The dissociation between arousal and strength may reflect an initial stage of expectancy-related physiological response. Understanding how belief relates to physiological markers may be important for interpreting wearable-derived outcomes in research and applied sport settings.

Keywords: Wearable exercise devices; Expectancy effects; Physiological arousal; Resting heart rate; Hand grip strength

Introduction

Wearable devices such as smart rings, watches, and activity trackers have shifted from lifestyle accessories to tools used in health promotion, clinical monitoring, and exercise science. Adoption continues to rise internationally, with meta-analytic evidence showing measurable effects on activity behavior in diverse populations (Au et al., 2024; Ferguson et al., 2022). These devices record steps, heart rate, sleep stages, and in some models oxygen saturation or heart rate variability, providing feedback for users and clinicians. In research and rehabilitation contexts, wearables have been integrated into structured programs to increase adherence to physical activity prescriptions and improve physical function (Ferguson et al., 2022; Szeto et al., 2023). They have also been used to support changes in sleep and behavior (Browne et al., 2021). Systematic reviews indicate that wearable-based interventions can produce short-term increases in activity and reduce cardiometabolic risk factors such as BMI, HbA1c, and blood pressure when combined with other behavioral strategies (Au et al., 2024; Heizmann et al., 2023).

Most studies focus on behavioral outcomes, including step counts and reduced sedentary time, while giving less attention to whether belief in a device, separate from its function, can influence physiological or performance measures. Research in placebo science suggests this is plausible. Expectancy can alter cardiovascular and autonomic responses and may affect performance in sport contexts (Chhabra & Szabo, 2024; Hurst et al., 2020). In resistance training, participants who were told they were receiving a special intervention improved strength more than controls despite identical training (Lindberg et al., 2023). Similar effects have been reported with

manipulated tracker feedback, where participants' beliefs about activity sufficiency influenced well-being and perceived health, even when activity levels did not change (Zahrt et al., 2023).

Experimental studies have begun to examine these expectancy effects directly. Placebo caffeine altered resting heart rate and RR intervals without improving strength or HRV outcomes (Ortiz-Sánchez et al., 2024). In children, deceptive placebos increased engagement during physical activity tasks (Stopper et al., 2024). Across this work, belief appears able to influence motivation and autonomic markers, though the impact on objective strength and endurance outcomes is mixed. Wearables may be particularly susceptible to expectancy because digital displays, biomedical language, and industrial design can convey technical authority and increase credibility (Chhabra & Szabo, 2024).

Physiological markers have been used to study expectancy mechanisms in prior work. Handgrip strength (HGS) reflects voluntary effort, muscular performance, and has been linked to functional capacity and mortality risk in clinical cohorts (Bohannon, 2019; Lee, 2021). Heart rate variability is used as an index of autonomic regulation and is applied in sport and clinical settings to monitor recovery or stress (Addleman et al., 2024). Wearable-derived HRV has shown agreement with ECG during resting and nocturnal conditions (Li et al., 2023; Theurl et al., 2023) and has been used to detect illness onset and support training adjustments in applied environments (El-Malahi et al., 2024; Sanches et al., 2023).

The present study uses a placebo-controlled crossover design to test whether belief in a wearable device can influence muscular performance and cardiovascular arousal, measured through handgrip strength and resting heart rate in healthy young adults. Expectancy-related contextual cues were introduced while device functionality remained constant, allowing the effects of device presence and scripted information to be examined independent of active device function. Clarifying expectancy effects in wearable research is relevant for sports medicine. It supports interpretation of performance metrics, informs integration of consumer devices into training and rehabilitation, and may help distinguish physiological adaptations from belief-driven responses.

Material & Methods

Participants

Twenty healthy adults (10 male, 10 female; aged 18–35 years) were recruited from the Los Angeles area through word-of-mouth and community flyers. Eligibility criteria included regular participation in structured physical activity at least twice per week and the absence of cardiovascular, pulmonary, metabolic, neurological, or musculoskeletal conditions that could limit maximal voluntary contraction or increase risk during testing. Participants reporting upper-limb injury or pain were excluded. All individuals completed the Physical Activity Readiness Questionnaire (PAR-Q) and an exercise-history survey before enrollment. All exploratory participants from UCLA provided written informed consent while ethical approval was obtained from UCLA (IRB: 11-003190). Off-site participants provided written informed consent and single IRB approval (sIRB: BRANY, NY, USA). Research practices were conducted in accordance with the ethical principles documented in the Declaration of Helsinki.

Protocol and Assessments

This study used a single-session, randomized, placebo-controlled, within-subject crossover design to isolate expectancy effects from true device function. Each participant completed three counterbalanced conditions: (1) a control condition (no device), (2) a ring-only condition (an inactive smart ring worn without explanation), and (3) a ring-plus-script condition (the same inactive ring paired with a standardized verbal expectancy statement). To minimize order effects and ensure uniform expectancy exposure across participants, the scripted condition was administered last for all participants, a strategy consistent with recommendations to control carryover and demand characteristics in crossover designs (Wellek & Blettner, 2012). The smart ring was visually identical to a commercially available model but internally disabled to remove any physiological influence. This design minimizes interindividual variability and is widely used to detect small expectancy-related effects in exercise and placebo studies (Davenport et al., 2020; Rohloff et al., 2022).

Testing was conducted in a temperature-controlled, quiet, windowless room at an off-site fitness facility. Upon arrival, participants' height and body mass were measured using a calibrated stadiometer and scale, and body composition was assessed using multifrequency bioelectrical impedance analysis (InBody 720; InBody Co., Seoul, Korea) according to standardized pre-assessment procedures (Heyward, 2001). Participants then rested quietly for 20 minutes to stabilize autonomic tone before each condition.

Resting heart rate (HR) was recorded using a Polar H10 chest-strap monitor (Polar Electro, Kempele, Finland). The H10 provides R–R interval accuracy comparable to electrocardiography in resting and exercise conditions (Gilgen-Ammann et al., 2019; Schaffarczyk et al., 2022). HGS was measured using a Jamar hydraulic dynamometer (Patterson Medical, Warrenville, IL) following standardized testing procedures (Hamilton et al., 1994; Roberts et al., 2011). Participants were seated using the dominant hand with the shoulder neutral, elbow flexed to 90°, and wrist in 0–30° extension. Each condition included three maximal voluntary contractions of three seconds each, separated by 30-second rest intervals. The mean of the three trials was used for analysis. Ninety seconds of rest between conditions minimized fatigue effects. This protocol provides high test–retest reliability (intraclass correlation > 0.93) in young adults (Bohannon, 2019; Mathiowetz et al., 1985).

The wearable ring (Circul Ring, Bodimetrics, USA, CA, Los Angeles) was placed on the index finger opposite to the hand used for HGS measurement. This placement was chosen to avoid interference with the HGS measurement and ensure accurate data collection. The ring is made of stainless steel with an epoxy coating, providing durability and a sleek finish. It features adaptive sizing, allowing the ring to adjust comfortably to different finger sizes for a secure and personalized fit.

In the expectancy condition, participants were read a standardized statement describing the ring as a “bioelectrical stimulation and microvascular enhancement technology designed to optimize neuromuscular performance.” The full script is provided in Supplementary Material A for replication. Delivery was standardized across sessions by a single trained investigator, following guidelines for placebo manipulations in exercise science (Davenport et al., 2020; Rohloff et al., 2022).

Primary outcomes were handgrip strength (kg) and resting HR (beats per minute). All procedures followed international standards for grip-strength and HR assessment to ensure cross-study comparability (Electrophysiology, 1996; Roberts et al., 2011).

Statistics

Descriptive statistics are presented as mean, standard deviation (SD) and 95% confidence Interval (95% CI). Data did not deviate significantly from normality per Shapiro-Wilk tests. A one-way repeated measures analysis of variance (ANOVA) was utilized to compare hand grip strength and heart rate between the three groups. If the omnibus test was significant, then post hoc pairwise tests with a Bonferroni correction were performed. Effect size of the omnibus test was denoted as η^2 . Statistical significance was set at an alpha level of 0.05. All analyses were performed using R version 4.5.0 (R Foundation for Statistical Computing, Vienna, Austria)

Results

Participant characteristics and data completeness

Twenty healthy adults (10 male, 10 female; 18–35 years) completed all three conditions within a single laboratory session. All participants had complete HGS data. HR data was unavailable for six participants because of signal loss or synchronization failure during testing, leaving fourteen participants with complete HR records for all conditions. Descriptive statistics for handgrip strength and resting heart rate across experimental conditions are presented in Table 1.

Handgrip strength

Mean HGS was 35.45 ± 10.47 kg in the control condition, 36.47 ± 11.50 kg in the ring-only condition, and 35.83 ± 10.82 kg in the ring-plus-script condition ($n = 20$). A one-way repeated-measures ANOVA indicated no significant effect of condition on HGS ($p = 0.21$). Because the omnibus test was not found to be significant no further comparisons were made with HGS.

Heart rate

Analyses included fourteen participants with complete HR data. Mean resting HR was 92.57 ± 14.85 bpm in control, 99.79 ± 17.08 bpm in ring-only, and 98.21 ± 16.77 bpm in ring-plus-script. A repeated-measures ANOVA demonstrated a significant effect of condition on HR ($p < 0.001$; $\eta^2 = 0.42$). Bonferroni-adjusted pairwise comparisons showed that HR was significantly higher in both the ring-only ($p=0.005$) and ring-plus-script ($p=0.006$) conditions compared with control. HR did not differ between the ring-only and ring-plus-script conditions ($p = 1.000$).

Table 1. Handgrip strength and heart rate across experimental conditions

Outcomes	Condition	Mean $\pm$ SD	95% CI	n
HGS (KG)	Control	35.45 ± 10.47	30.69 – 40.22	20
	Ring-only	36.47 ± 11.50	31.24 – 41.70	20
	Script	35.83 ± 10.82	30.91 – 40.76	20
HR (bpm)	Control	92.57 ± 14.85	84.00 – 101.14	14
	Ring-only	99.79 ± 17.08	89.93 – 109.64	14
	Script	98.21 ± 16.77	88.53 – 107.89	14

Note: Values represent mean $\pm$ standard deviation and 95% confidence intervals around the condition mean. HGS = handgrip strength; HR = heart rate.

Discussion

This study examined whether expectancy associated with a wearable device could produce measurable changes in muscular performance or physiological arousal independent of true device functionality. Handgrip strength did not differ across conditions ($p = 0.21$), indicating that a single exposure to a wearable paired with a persuasive script was not sufficient to enhance maximal voluntary force production in healthy adults. In contrast, resting heart rate increased across conditions relative to control during the same laboratory session ($p < 0.001$; $\eta^2 = 0.42$). Similar patterns have been noted in placebo studies where belief in a substance altered cardiovascular responses without improving strength outcomes (Beedie et al., 2006; Duncan et al., 2009), suggesting that expectancy may influence arousal state even when objective performance remains unchanged.

The dissociation between unchanged strength output and increased heart rate suggests that contextual expectancy may influence physiological arousal without translating to acute changes in mechanical performance (Beedie et al., 2006; Duncan et al., 2009). Heart rate increases are often interpreted as reflecting a shift in arousal state, including reduced parasympathetic influence or greater sympathetic drive (Shaffer & Ginsberg, 2017), although the present study did not measure specific autonomic indices directly.

The study design also informs this interpretation. The scripted condition was presented last for all participants, which ensured that the expectancy manipulation was delivered consistently and reduced the possibility of carryover effects. Because control and ring-only conditions were counterbalanced while the script condition was held constant at the final exposure, any order effects would be expected to influence both earlier conditions similarly, which was not observed. The finding that both the ring-only and ring-plus-script conditions differed significantly from control (ring-only vs control: $p = 0.005$; ring-plus-script vs control: $p = 0.006$), while ring-only and ring-plus-script did not differ ($p = 1.00$), indicates that the presence of the wearable itself may have contributed to the cardiovascular response, with no added effect of the script.

Prior placebo research has documented that belief about substances or technology can alter physiological markers associated with arousal even without improving force production (Beedie et al., 2006; Duncan et al., 2009). Hurst et al. (2020) demonstrated that expectancy influenced perceived vigor and motivation despite no gains in torque or power, reinforcing the idea that early expectancy responses may emerge first in physiological or perceptual domains. The persuasive framing used in the expectancy script does not appear to have produced effects beyond those observed with device presence alone, suggesting that the wearable context itself may have driven the observed physiological response. Geers et al. (2018) demonstrated that scientific or biomedical terminology, including references to physiological processes such as “bioelectrical stimulation,” can increase placebo responses by conferring credibility and discouraging critical evaluation.

The lack of measurable strength enhancement aligns with research suggesting that expectancy-related performance differences may require repeated exposure or reinforcement to manifest behaviorally. Lindberg et al. (2023) reported that belief-related strength effects emerged during multiweek resistance training but did not alter immediate maximal efforts, implying that accumulated expectancy learning plays a role in behavioral change. This pattern of increased arousal without behavioral change may reflect an early phase of expectancy response, with later behavioral effects requiring reinforcement.

Several mechanisms have been proposed to explain expectancy-related changes in physiological arousal. Placebo-induced activation has been described in pharmacological and exercise research (Colloca & Miller, 2011; Benedetti, 2013), suggesting that belief may influence physiological readiness through top-down pathways. In the context of wearables, device characteristics such as technical language, visual cues, and design features have been suggested to amplify expectancy responses (Chhabra & Szabo, 2024). However, these mechanisms cannot be inferred from the current data, since autonomic markers such as heart rate variability were not collected. The growing integration of wearable technologies into sports and rehabilitation underscores the importance of considering expectancy when interpreting physiological data. If belief in a device influences arousal to a measurable degree, this may introduce variability into performance assessments or physiological monitoring (Enck et al., 2013). Clear communication and controlled evaluation may therefore be useful when integrating consumer devices into training environments.

Several limitations should be acknowledged. The sample size limits the ability to detect small effects, and heart rate analyses included fourteen participants due to signal loss, which reduces precision. The study examined acute exposure in a controlled setting using a single maximal strength test. Future research should incorporate continuous autonomic monitoring, including heart rate variability and electrodermal activity, as well as perceptual outcomes to clarify whether expectancy interacts with motivation, stress, or effort. Multi-session designs and ecologically valid contexts may also provide insight into whether expectancy effects accumulate over time.

Conclusion

Expectancy associated with a wearable device was linked to a significant increase in resting heart rate without improvement in handgrip strength during acute assessment. These findings suggest that the presence of a wearable device, even in the absence of active functionality, can influence physiological arousal during early exposure, while not translating to enhanced maximal strength output. The dissociation between increased cardiovascular arousal and unchanged strength performance highlights that belief- or context-driven physiological responses may emerge before measurable changes in voluntary force production. As wearable technologies continue to be integrated into sport, rehabilitation, and health monitoring, understanding how expectancy and device context influence physiological markers will be important for accurately interpreting wearable-derived data and distinguishing true physiological adaptations from belief-related effects. Future studies should examine whether these arousal effects persist with repeated exposure, interact with motivation or perception, or influence performance outcomes over longer time scales and in more ecologically valid settings.

Conflicts of interest We declare no conflicts of interest.

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