Effect of Mirthful Laughter on Vascular Function

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In contrast to the well-established scientific evidence linking negative emotional states (e.g., depression, anxiety, or anger) to increased risk for cardiovascular disease, much less is known about the association between positive emotional states (e.g., laughter, happiness) and cardiovascular health. We determined the effects of mirthful laughter, elicited by watching comic movies, on endothelial function and central artery compliance. Seventeen apparently healthy adults (23 to 42 years of age) watched 30 minutes of a comedy or a documentary (control) on separate days (crossover design). Heart rate and blood pressure increased significantly while watching the comedy, whereas no such changes were seen while watching the documentary. Ischemia-induced brachial artery flow-mediated vasodilation (by B-mode ultrasound imaging) increased significantly after watching the comedy (17%) and decreased with watching the documentary (−15%). Carotid arterial compliance (by simultaneous application of ultrasound imaging and applanation tonometry) increased (10%) significantly immediately after watching the comedy and returned to baseline 24 hours after the watching, whereas it did not change significantly throughout the documentary condition. Comedy-induced changes in arterial compliance were significantly associated with baseline flow-mediated dilation (r = 0.63). These results suggest that mirthful laughter elicited by comic movies induces beneficial impact on vascular function. **(Am J Cardiol 2010;106:856–859)**

Not much is known about the association between positive emotional state (e.g., laughter, happiness) and cardiovascular health. The primary purpose of the present study was to determine the effect of mirthful laughter, elicited by watching comedy, on vascular function as determined by arterial stiffness and flow-mediated dilatation (FMD). Watching of a documentary was used as a control condition. In addition, to gain insight into the magnitude of cardiovascular changes during mirthful laughter, heart rate and blood pressure were continuously monitored using a beat-to-beat blood pressure device.

Methods

Seventeen sedentary or recreationally active adults (12 men and 5 women) 23 to 41 years of age (mean 26 ± 1 years) were studied. Participants were apparently healthy, normotensive, nonobese (body mass index 23.0 ± 0.5 kg/m^2), nonmedicated, nonsmokers, and free of overt cardiovascular disease (Table 1). Susceptibility of subjects to laugh was evaluated using a cheerfulness questionnaire.[1] Candidates who marked "strongly disagree" on the questions "Everyday life often gives me the occasion to laugh" and "I like to laugh and do it often" were excluded. This was done to ensure that watching a comedy would elicit mirthful laughter. The study was reviewed and approved by the institutional review board. All subjects gave their informed consent to participate.

Participants were required to fast and abstain from caffeinated beverages for ≥4 hours before experiments. Participants were instructed not to engage in any strenuous physical activity and drink alcohol for 24 hours before the study. In addition, testing was initiated at the same time of day for each subject throughout the study period to avoid potential diurnal variations. After 15 minutes of rest in a supine position, baseline measurements of heart rate, blood pressure, and vascular function were performed. Subsequently, each subject watched 30 minutes of a comedy or documentary from a digital video disk (DVD; crossover design) in the laboratory room alone. Because sense of humor differs, each subject selected a favorite comedy program from the laboratory DVD collection that includes stand-up comedy programs featuring Jerry Seinfeld, Ellen Degeneres, Bill Cosby, so on. Otherwise, subjects brought their favorite comedy programs. In the documentary session, each subject chose a documentary from the laboratory DVD collection (e.g., economy, history, natural science, so on).

Brachial blood pressure was measured in triplicate from the right arm in a supine position with an automated oscillometric device (HEM-907XL, OMRON Healthcare, Vernon Hills, Illinois). Throughout viewing a movie, beat-to-beat finger blood pressure was continuously recorded with a photoplethysmograph (Portapres, TNO TPD Biomedical Instruments, Amsterdam, The Netherlands) and personal computing software (BeatScope 1.0, TNO TPD Biomedical Instruments, Amsterdam, The Netherlands).

Carotid artery compliance was obtained with a combination of ultrasound imaging of the common carotid artery (by B-mode ultrasound [iE 33, Philips, Bothell, Washington] equipped with a 15-MHz linear array transducer) and recording of contralateral carotid arterial pressure (by appla-

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Table 1
Changes in heart rate and brachial blood pressure in response to watching a documentary and a comedy

Variables	Session	Baseline	After 5 Minutes	After 30 Minutes	After 24 Hours
Heart rate (beats/min)	documentary	51 ± 3	51 ± 4	53 ± 4	52 ± 3
	comedy	54 ± 2	56 ± 2	55 ± 2	54 ± 2
Systolic blood pressure (mm Hg)	documentary	114 ± 3	113 ± 3	112 ± 3	112 ± 3
	comedy	112 ± 2	112 ± 2	110 ± 2	111 ± 2
Diastolic blood pressure (mm Hg)	documentary	60 ± 2	59 ± 2	58 ± 2	59 ± 2
	comedy	59 ± 2	60 ± 2	58 ± 2	59 ± 2
Mean blood pressure (mm Hg)	documentary	78 ± 2	77 ± 2	77 ± 2	77 ± 2
	comedy	77 ± 2	77 ± 2	75 ± 2	76 ± 2
Pulse pressure (mm Hg)	documentary	54 ± 3	54 ± 3	55 ± 3	54 ± 3
	comedy	52 ± 2	52 ± 2	52 ± 2	53 ± 2

Data are means ± SEMs. No variable changed significantly throughout the protocol.

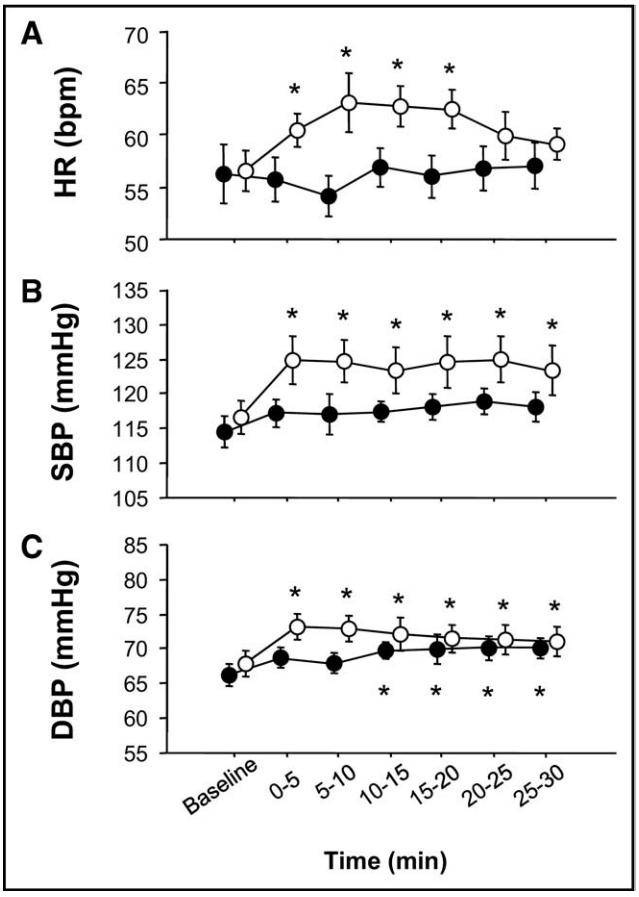

Figure 1. *(A)* Heart rate (HR), *(B)* systolic blood pressure (SBP), and *(C)* diastolic blood pressure (DBP) while viewing a documentary *(closed circles)* or a comedy *(open circles)*. * $p < 0.05$ versus baseline.

nation tonometry; VP-2000, Colin Medical, San Antonio, Texas), as previously described.[2,3] All scans were performed by the same investigator who was blinded to the order of sessions. Day-to-day coefficient of variation for arterial compliance measurements was 5 ± 2%. Carotid arterial augmentation index, an index of arterial wave reflection that is influenced by arterial stiffness, was also obtained with arterial applanation tonometry as previously described.[4,5]

Brachial artery FMD measurements were performed according to an established procedure.[6] A longitudinal image of the brachial artery was acquired 5 to 10 cm proximal to the antecubital fossa of the left arm using the ultrasound machine equipped with the compact linear array transducer and a customized transducer-holding device. The location of the transducer was clearly marked with a permanent marker to ensure measurement at the same location throughout testing. Brachial artery diameter was continuously monitored until 90 seconds after blood reperfusion and analyzed using image analysis software (Brachial Analyzer, Medical Imaging Applications, Coralville, Iowa). The same investigator, who was blinded to experimental sessions, performed all image analyses.

A stretch-sensitive strain gauge (Pneumotrace II, UFI, Morro Bay, California) was wrapped around a subject's chest to quantify the number of laughs while watching the documentary and the comedy. The Pneumotrace analog signal was converted to a digital signal (WinDaq, DATAQ Instruments, Akron, Ohio) and recorded simultaneously on a computer for later analysis.

The Positive and Negative Affect Schedule score,[7] a 20-item questionnaire with positive and negative affect subscales, was used to assess changes in mental and mood states.

Analysis of variance and multivariate analysis of variance with Fischer's post hoc test were performed to compare mean values. Paired *t* test was applied to compare the number of laughs from the subjects. Wilcoxon matched-pairs test was used to evaluate changes in questionnaire-based psychological scales between before and after movie sessions. Pearson correlations and Spearman rank-order correlations were applied to determine relations.

Results

Number of laughs, as estimated by irregularity in respiration patterns, increased significantly while watching the comedy (97 ± 13 times), whereas watching the documentary did not disturb respiratory patterns significantly (5 ± 1 times). No significant correlations were observed between changes in vascular functions and number of laughs.

Watching comedy did not elicit significant changes in positive (16.8 ± 1.2 vs 17.3 ± 1.3) or negative (10.7 ± 0.3 vs 10.5 ± 0.2) mood scores. Watching a documentary significantly decreased positive mood (18.5 ± 1.3 vs 16.5 ± 1.5) but did not affect negative mood (10.8 ± 0.2 vs 10.9 ± 0.3). No significant correlations were observed between

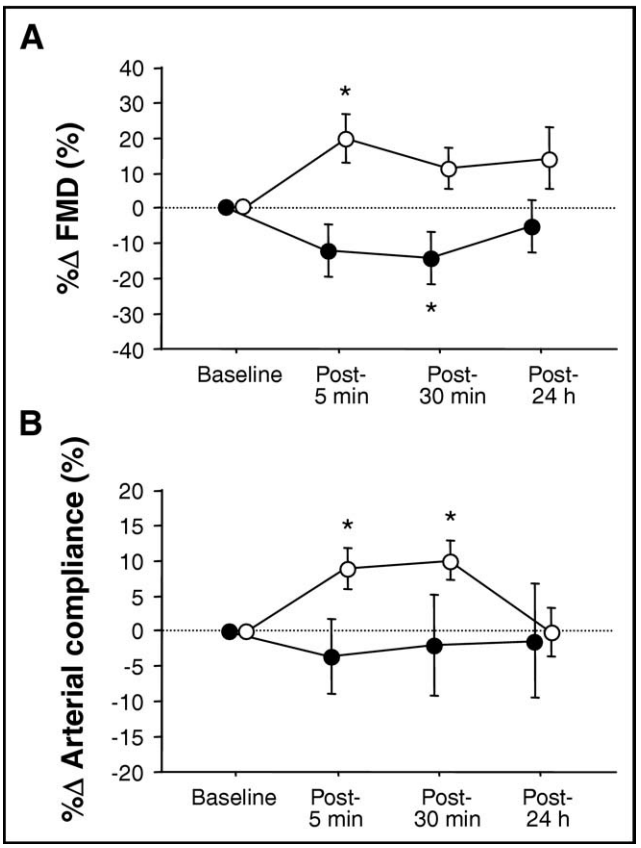

Figure 2. Relative (percent) changes (Δ) from baseline in brachial artery FMD *(A)* and carotid arterial compliance *(B)* in response to watching a documentary *(closed circles)* or a comedy *(open circles)*. * $p < 0.05$ versus baseline.

changes in vascular functions and positive or negative mood state.

While watching a documentary, heart rate and systolic blood pressure did not change significantly, but diastolic blood pressure increased slightly but significantly for the last 20 minutes (Figure 1). While watching a comedy, heart rate increased significantly in the initial 20 minutes, and systolic and diastolic blood pressures remained increased ($p < 0.05$) throughout the movie-watching session. Hear rate and blood pressure returned to baseline levels after watching the DVD.

Heart rate and brachial blood pressure did not change significantly throughout the protocol in either group (Table 1). There were no significant differences in diastolic brachial artery diameters and FMD (documentary 8.4 ± 0.5%, comedy 8.6 ± 0.9%) at baseline between sessions. Brachial artery diameter did not change significantly throughout the protocol in the comedy or documentary sessions. FMD increased significantly 5 minutes after watching a comedy and remained increased (+12%) until 24 hours after watching (Figure 2). While watching a documentary, FMD decreased, gradually reaching significance at 30 minutes after watching a movie, and returned to baseline at 24 hours.

Augmentation index decreased significantly 5 minutes after watching a comedy (Table 2). Carotid artery systolic blood pressure and pulse pressure did not change significantly throughout the protocol in the comedy or documentary sessions (Table 2). There was no significant difference in baseline carotid artery compliance between the documentary and comedy sessions (0.20 ± 0.01 vs 0.19 ± 0.01 mm^2/mm Hg). Carotid artery compliance increased significantly after watching a comedy (+10%) but did not change in the documentary session (Figure 2). Changes in artery compliance induced by watching a comedy were significantly associated with baseline FMD ($r = 0.63$, $p < 0.05$).

Discussion

The main finding from the present study using the random order, crossover design was that 30 minutes of viewing a comedy and the resultant mirthful laughter positively affected endothelium-dependent flow-mediated vasodilation and arterial stiffness. The favorable acute effect of laughter on vascular function disappeared within 24 hours. Taken together, these results indicate that the laughter produces beneficial but transient effects on vascular function in young healthy adults.

In contrast to accumulating evidence linking negative emotional states and vascular function, only 2 studies (1 on arterial stiffness[8] and 1 on endothelial function[9]) are available addressing the effect of positive emotional state and vascular function. As such, confirmation of these findings was critically needed. Miller et al[9] demonstrated that brachial artery FMD increased after watching a comedy and decreased after watching a mentally stressful movie. More recently, Vlachopoulos et al[8] reported that watching a comedy induced acute decreases in aortic stiffness and central wave reflection. Our present study extends previous studies in many important ways. First, we quantified and documented episodes of mirthful laughter using a stretch-sensitive strain gauge. Second, assessment of mood state changes allowed us to evaluate possible mind–body interactions between mood state and vascular function. Third, to determine how long the residual effects of laughter would persist, measurement of vascular function was repeated 24 hours later. Fourth, we used a more direct and robust measurement of arterial compliance to properly assess the elastic property of the arterial wall. Fifth, we implemented a tighter control of factors that could influence vascular function (e.g., medication use, diurnal variations, presence of others in the room, so on). We found that 30 minutes of watching a comedy induced significant transient increases in brachial artery FMD and arterial compliance. Collectively, these results suggest that mirthful laughter exerts beneficial effects acutely on vascular health.

We can only speculate on the mechanism underlying the improved vascular function with mirthful laughter. Subjects laughed ~100 times on average. Because the act of laughing is accompanied by contraction of thoracic, abdominal, and facial muscles, cardiac output and peripheral blood flow are expected to increase while watching a comedy. Indeed, heart rate and blood pressure increased significantly while viewing a comedy. It is plausible that repeated muscle contraction might have evoked increases in blood flow and shear stress and resultant production of nitric oxide. Alternatively, laughter may have evoked β-endorphin release from the pituitary gland, which activates $\mu 3$ opiate receptors that upregulate nitric oxide synthase, as previously hypoth-

Table 2
Changes in carotid artery properties in response to watching a documentary and a comedy

Variables	Session	Baseline	After 5 Minutes	After 30 Minutes	After 24 Hours
Systolic blood pressure (mm Hg)	documentary	102 ± 3	103 ± 4	101 ± 3	101 ± 3
	comedy	101 ± 3	100 ± 2	98 ± 2	100 ± 2
Pulse pressure (mm Hg)	documentary	40 ± 4	42 ± 4	41 ± 3	41 ± 3
	comedy	41 ± 3	39 ± 2	39 ± 2	40 ± 2
Diastolic diameter (mm)	documentary	6.83 ± 0.19	6.95 ± 0.19*	6.95 ± 0.18*	6.79 ± 0.15
	comedy	6.68 ± 0.11	6.81 ± 0.10*	6.85 ± 0.12*	6.67 ± 0.10
Systolic diameter (mm)	documentary	7.39 ± 0.10	7.54 ± 0.10	7.58 ± 0.11	7.37 ± 0.10
	comedy	7.58 ± 0.17	7.66 ± 0.17*	7.66 ± 0.15*	7.52 ± 0.12
Augmentation index (%)	documentary	0.5 ± 4.8	1.4 ± 5.1	−2.8 ± 5.0	−5.3 ± 3.3*
	comedy	−1.9 ± 2.7	−5.7 ± 2.8*	−4.8 ± 2.8	−3.7 ± 2.4

Data are means ± SEMs.
* $p < 0.05$ versus baseline.

esized.[10] Although no changes in mood state scores and no association between changes in mood state and vascular function observed in the present study are not consistent with this hypothesis, the questionnaire used in the present study may not have been sensitive enough to detect mood state changes. Alternatively, it may be the physical act of laughter, not the change in mood state, that is driving the changes in vascular function.

Although watching a comedy induced significant increases in vascular function, such effects disappeared within 24 hours. One may argue that this short-acting effect of laughter may limit the utility of incorporating laughter into a preventive and treatment strategy for vascular dysfunction. However, a recent epidemiologic study has indicated that an increased positive affect is protective against 10-year incident coronary heart disease.[11] In this context, a discussion on acute and long-term physical activity, which has been compared to laughter repeatedly in lay publications, may be helpful. A single (acute) bout of exercise evokes changes in a variety of risk factors for cardiovascular disease. These acute effects of exercise dissipate rapidly before the next bout of physical activity is performed.[12] However, over time, these acute effects accumulate to constitute long-term effects. Interestingly, the magnitude of changes induced by long-term exercise training is highly comparable to those achieved acutely by 1 bout of exercise.[13] To the best of our knowledge, no laughter intervention studies that focusing on vascular function or cardiovascular disease risks have been conducted to date.

It is not clear why brachial artery FMD decreased after viewing a documentary. Some documentaries (e.g., *Iraq for Sale* and *Wal-Mart: The High Cost of the Low Price*) contained segments that could induce negative emotional states, such as anger or frustration. Such emotional stress might have translated into a decreased FMD observed in this study.

Several limitations of this study should be noted. We studied young healthy adults who had normal endothelial function and arterial compliance. Thus, the results cannot be extrapolated to older and/or patient populations, and one may argue that the effects would be greater in such subjects. However, the magnitude of improvement in arterial compliance induced by watching a comedy was positively associated with baseline endothelial function, indicating that a healthier endothelium may be necessary to elicit beneficial effects on macrovascular function. If so, the act of laughter might provide less benefit to older and/or patient populations whose endothelial function is significantly decreased.

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