 Reported and Measured Physical Functioning in Older Inner-City Diabetic African Americans

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Background. The impact of diabetes on disability and physical functioning in older African Americans and potential causes of the excessive disability associated with diabetes in other studies have been inadequately investigated.

Methods. A population-based survey was performed comparing 116 self-reported diabetic inner-city African Americans aged 70 years and older to 522 nondiabetic persons from the same population. A subsample (n = 168) received a physical examination focused on body habitus, upper and lower body strength, balance, and timed physical performance tasks. Blood tests were obtained from 173 subjects.

Results. Diabetic individuals reported worse general health (p = .01), instrumental activities of daily living (p = .02), and modified versions of the Rosow-Breslau scale (p < .001) and the Stanford Health Assessment Questionnaire (p = .002). Diabetic persons also reported more falls (0.59 per person vs 0.20, p = .019) and injurious falls (12% vs 6%, p = .025). There were minimal differences in the strength, balance, and timed performance measures (analyzed separately by gender). In multivariable analyses, impairments in visual function and pain and light touch perception appeared to explain some of the association between diabetic status and poor general health, disability, and falls, with lesser contribution from the number of medical problems, number of medications, and glycemic control.

Conclusions. Older inner-city diabetic blacks demonstrated worse general health, excess disability, and more falls compared to controls, although deficits in strength, balance, and timed performance could not be demonstrated. The cause of decreased functional status in diabetic elders deserves additional investigation, focusing especially on sensory function, glycemic control, and contribution from specific medical problems and medications.

The prevalence of diabetes mellitus increases with age (1), and nearly one half of all individuals with Type II diabetes mellitus are over 65 years old (2). Studies have suggested that a number of differences exist between middle-aged and older diabetic persons (3,4). In particular, older Type II diabetic individuals are less likely to be overweight (5,6), evidence a greater risk for developing dehydration (7,8), have increased prevalence of gastrointestinal symptoms (9), and are more likely to have nutritional deficiencies [e.g., zinc deficiency; (10,11)] than their younger counterparts. In addition, diabetes is more common among African Americans than whites (1,12). Despite these statistics, most studies of Type II diabetes mellitus have involved middle-aged white diabetic persons. There is minimal information available on older African Americans with diabetes.

Epidemiological studies using survey questions have demonstrated worse self-reported functional status in people with diabetes than in those without diabetes. For example, diabetic individuals report more activity limitations, work disability, and dependency on others to conduct their activities of daily living (ADLs). Not surprisingly, diabetic persons reporting these problems rate their general health status much worse than persons without them (12). However, studies investigating the physical, emotional, and social reasons for the increased disability in diabetic persons are rare. It has been shown that there is an increase in the prevalence of neuropathic morbidity with increasing age in diabetic patients (13), and the presence of sensory neuropathy puts diabetic persons at increased risk of falling compared to either diabetic individuals without neuropathy or nondiabetic controls (14,15). In young diabetic patients, neuropathy has been associated with a significant increase in injurious falls while walking (16). A recent study in Mexico City found that diabetes was associated with more adverse health consequences for lower than higher socioeconomic groups (17).

Our studies of inner-city African Americans in the St. Louis metropolitan area have shown that this group has a high degree of functional disability (18) and has much higher nutritional risk than do Caucasians (19). In view of the paucity of data available on the effects of diabetes mellitus in older African Americans, we undertook an analysis of the effects of diabetes on functional status and falls in our inner-city population. As part of this analysis, we looked for anthropometric, emotional, cognitive, and physical functioning factors that might help explain any differences identified in reported functional status between diabetic and nondiabetic individuals.

METHODS

Subjects.—Subjects were noninstitutionalized, self-described black or African American, 70 years of age or older, and living in a 5-square-mile catchment area of north St. Louis (18). We recruited 416 subjects using a random sample frame developed from Health Care Financing Administration (HCFA) lists (the "random group"); 230 were recruited from area senior citizen apartments and programs sponsored by local community health centers (the "program group") for a total of 646. Trained assistants obtained interviews from subjects (97%) or from primary
caregivers (3%) using a structured protocol. Detailed evaluations of strength and balance were performed on 168 (91 random, 77 program) subjects using standardized protocols. Approximately one half of the measures were always obtained by one of the investigators (DKM), and the other one half by a research assistant rigorously trained in these procedures. Strength and balance participants were substantially similar to those subjects not participating in this portion of the study (manuscript in review). Blood was obtained for laboratory testing on 173 subjects (146 received strength and balance examinations and 27 did not). Approval was obtained from the St. Louis University Health Sciences Center’s Institutional Review Board for all research procedures, and informed consent was obtained from all participants.

Measurement.—Subjects were queried specifically as to whether they had diabetes mellitus or sugar diabetes. Current medication use and whether prescription, over-the-counter, daily or taken on an as-needed basis were obtained by self-report with general probes for additional medications and specific probes based on reported medical problems. In 83% of interviews a review of the actual medication containers was also performed. Subjects were considered to have “self-reported diabetes” if they reported having diabetes or were noted to take a hypoglycemic agent. Information was available to define the presence of self-reported diabetes in 638 (99%) of the 646 subjects. Albumin-corrected fructosamine was available for 172 subjects. Most analyses were performed based on self-reported diabetes rather than a definition that included fructosamine to conserve sample size when examining the relationship between diabetes and functional status and to permit comparisons with prior studies based on self-report of diabetes (17,20,21).

Age was based on the subject’s date of birth at the time of the interview. Medical diagnoses were based on self-report with structured probing for diabetes, stroke, hypertension, heart disease, kidney disease, lung disease, liver disease, and arthritis. Self-rated health was based on a question from the Established Populations for the Epidemiologic Studies of the Elderly (EPESE) study (22) using five response categories (excellent, very good, good, fair, and poor). Self-reports regarding vision and hearing were also obtained using the same five response categories. Assessment of nocturia was based on the method of Stewart and colleagues (23). History of stroke, urinary incontinence, presence of persistent back or joint pains, and use of alcohol and cigarettes were assessed using questions from EPSE study (22). Questions from Tinetti and coworkers (24) were used to obtain information about falling over the past 3 months. A fall was considered injurious if the subject was unable to arise alone after a fall, cut down on usual activities after the fall, or sought medical attention.

The modified Rosow-Breslau scale was determined using the method of Guralnik and colleagues (25) and scored 0 to 3 as inability to (a) walk up and down a full flight of stairs, (b) walk one half mile, or (c) do heavy work around the house without assistance. Basic ADLs (BADLs) were measured using five items (bathing, dressing, transferring, toileting, and feeding) from the Katz scale (26), and instrumental ADLs (IADLs) were measured using the Lawton and Brody scale (27); both scales were scored as the number of items requiring personal assistance. Three items from the modified Stanford Health Assessment Questionnaire (MHAQ) developed by Pincus and colleagues (28) that did not overlap the Rosow-Breslau or ADL scales (opening jars with tight lids, picking up clothes from the floor, and having difficulty getting in and out of a car) were used to construct a subscale of the MHAQ in which independence was scored 1, requiring personal assistance scored as 2, and inability to perform the activity even with help was scored as 3, with a resulting range of possible scores from 3 to 9. In this report this scale will be identified as the Pincus-3 scale. Interviewers also obtained the Geriatric Depression Scale [GDS; (29)] and a structured form (30) of the Mini-Mental State Examination [MMSE; (31)].

All physical measurements were obtained without knowledge of results of the interview to prevent contamination of findings. Specifically, subjects participating in the strength and balance evaluation were not asked whether they had diabetes. Body mass index (BMI) was determined as weight divided by height squared using metric measurements (32). Waist was measured at the narrowest horizontal circumference between the ribs and iliac crest, abdomen at the largest horizontal circumference between the ribs and iliac crest, and hip at the maximal horizontal circumference at the buttock level (33). Both feet and both ankles were closely evaluated for the presence of any ulceration, and pin-prick, light touch, position sense, and plantar reflexes were measured using standard examination techniques. Vibration time was measured as the longest time vibration from a 128-frequency tuning fork was felt in each lateral malleolus after a maximum strike on the fork and then averaged. Grip strength was measured in kilograms using the method of Balogun and coworkers (34) and the Jamar dynamometer [JA Preston Corp., Bolingbrook, IL; (35)]. The strength of shoulder abduction, knee extension, hip flexion, hip extension, and hip abduction was measured using body positioning as suggested by Kendall and colleagues (36). The “break” form of testing was employed because pilot testing showed that subjects understood this approach better than the “make” approach. Strength of the stronger extremity was measured in pounds using the MicroFet hand-held dynamometer [Hogan Health Industries, Draper, UT; (37)]. MicroFet readings were adjusted for weight as suggested by Brown and coworkers (38).

Balance was tested using the Performance-Oriented Assessment of Mobility (POAM) scale (39), scored from 0 (worst) to 28 (best); standing balance scale developed by Guralnik and colleagues (40), scored from 0 (worst) to 4 (best); and timed one-leg balance with eyes open (41). Timed functional performance measures included customary gait speed (42) over a 6-meter course; timed Up & Go test [in which the subject rises from a chair, walks 3 meters, and then returns and sits in the chair as quickly as possible; (43)]; and the 7-item Physical Performance Test of Reuben and Siu (44) that included timed measurement of lifting a book, writing a sentence, simulating eating, putting on and taking off a jacket, picking a penny up from the floor, and usual walking speed plus a rating for stability of turning during walking (scored 0–28). During the strength and balance assessment, subjects were queried as to whether they had ever had a heart attack or currently experienced heart pains or angina.

Standard chemistries were obtained from a reliable commercial laboratory. Albumin-corrected fructosamine was measured using the methods of Negoro and colleagues (45) and Furrier (46).

Statistical analysis.—Testing for statistically significant differences between groups included chi-square for categorical variables and Student’s t test for continuous variables with approximately
normal distributions. For variables with skewed distributions (falls, creatinine, timed one-leg stand, and Up & Go tests), analyses were based on log-normal transformations, which produced approximately normal distributions. (Nonparametric procedures produced similar results and are available from the first author.)

In an attempt to better understand why diabetic individuals fared worse on self-reported functional outcomes than did nondiabetic controls, multivariable models were constructed with the outcomes as dependent variable, controlling sequentially for factors that might help explain the relationship (age, gender, BMI, abdomen-to-hip ratio [AHR], stroke, self-reported visual function, light touch and pain sensation in the feet, number of medical problems other than diabetes, and number of daily medications) based on the bivariable results and clinical judgment. In the first set of analyses, diabetic status was the first independent variable entered, followed by the other potentially explanatory variables (47). In the second set of analyses, albumin-adjusted fructosamine was substituted for diabetic status to evaluate whether the presence of diabetes or diabetic control appeared to be the more important factor. Ordinary least squares regression was used for continuous outcomes (IADL functioning, Rosow-Breslau, and Pincus-3) and reported as the standardized beta. (Unstandardized betas are available from the first author.) Logistic regression was used for dichotomous outcomes (fair or poor self-rated health and whether the subject reported one or more falls).

RESULTS

A history of diabetes mellitus was obtained from 112 subjects. An additional four individuals were found to be taking diabetic medications although they did not report having the diagnosis, resulting in 116 diabetic subjects (18.2%) and 522 nondiabetic subjects (81.8%) by historical criteria. In those participants in whom fructosamine was available (n = 172), 25% of subjects would have been identified as having diabetes if the criterion of an elevated fructosamine level (45,46) was added to the diabetic diagnosis and diabetic medication criteria.

The diabetic group was slightly younger, reported more medical problems, ingested more medications, was more likely to have heart attacks and angina, drank less, reported diminished vision more frequently, and was more likely to have foot or ankle ulcerations (Table 1). The number of medical problems differed between the two groups even when the diagnosis of diabetes was deleted from the sum (p = .043). Diabetic persons did not differ from the rest of the sample as far as gender or history of stroke, cigarette use, hearing, urinary incontinence, nocturia, or joint or back pain. Both male and female diabetic subjects had elevated BMI, waist-to-hip ratio (WHR), and AHR compared to nondiabetic controls, although the differences in females did not reach conventional levels of statistical significance, perhaps due in part to the drop in sample size because of the relatively small number of examined subjects and the split by gender (Table 1). Diabetic subjects more often had deficits in pin-prick and light touch sensation in the feet, but position sense, plantar reflexes, and vibration time were not significantly different between the two groups. The majority of diabetic subjects were not obese (Figure 1); only 38.5% were found to have a BMI greater than 32 (48).

| Table 1. Standard Medical Variables in Self-Reported Diabetic and Nondiabetic Subjects |
|---------------------------------|----------------|----------------|----------------|
|                                 | Diabetic (%)  | Not Diabetic (%) | p value      |
| Age (yr)                        | 79.1 (6.25)   | 80.67 (7.27)    | .009         |
| Women (%)                       | 76.0          | 69.9            | .72          |
| No. of medical problems (%)     | 3.32 (1.29)   | 2.04 (1.36)     | <0.001       |
| No. of daily medications (%)    | 4.36 (2.45)   | 2.40 (2.23)     | <0.001       |
| History of heart attack (%)     | 34.8          | 15.30           | .024         |
| History of angina (%)           | 34.8          | 14.70           | .018         |
| History of stroke (%)           | 12.90         | 8.40            | .130         |
| Pack-years H/O smoking (%)      | 12.74 (26.29) | 13.34 (25.67)   | .678         |
| No. of alcoholic drinks/wk      | 0.21 (16.6)   | 0.96 (11.5)     | .011         |
| Fair or poor vision (%)         | 50.00         | 39.80           | .044         |
| Fair or poor hearing (%)        | 22.40         | 24.60           | .624         |
| Uroinary incontinence (%)       | 7.00          | 6.40            | .807         |
| Nocturia (no. /night)           | 2.14 (1.53)   | 1.98 (1.51)     | .315         |
| Joint pains (%)                 | 62.10         | 55.00           | .164         |
| Persistent back pains (%)       | 44.00         | 35.30           | .078         |
| BMI - Women*                    | 31.44 (4.96)  | 29.87 (6.90)    | .290         |
| BMI - Men†                      | 29.96 (7.69)  | 24.26 (3.52)    | .011         |
| WHR - Women*                    | 0.874 (0.081) | 0.841 (0.071)   | .178         |
| WHR - Men†                      | 0.960 (0.056) | 0.905 (0.073)   | .017         |
| AHR - Women*                    | 0.994 (0.083) | 0.962 (0.075)   | .304         |
| AHR - Men†                      | 1.016 (0.050) | 0.948 (0.067)   | .004         |
| Diminishing pin-prick at feet (%)| 34.8          | 14.3            | .016         |
| Diminishing light touch at feet (%)| 39.1        | 19.9            | .040         |
| Diminishing position sense in toes (%)| 21.7       | 17.7            | .645         |
| Babinski reflex present on either side (%)| 13.6      | 9.0             | .495         |
| Vibration time with 128 fork (s)†| 10.1 (5.21)  | 9.6 (4.75)      | .676         |
| Foot-ankle ulceration (%)       | 8.70          | 1.40            | .034         |

Notes: H/O = history of; BMI = body mass index; WHR = waist-to-hip ratio; AHR = abdomen-to-hip ratio. Unless noted, data entries are mean (SD), and sample sizes are 112–116 diabetic subjects and 510–522 nondiabetic subjects.

* = 15 diabetic subjects and 93 nondiabetic subjects.
† = 22–23 diabetic subjects and 139–144 nondiabetic subjects.
‡ = 9 diabetic subjects and 46 nondiabetic subjects.

Figure 1. Body mass index (BMI) distributions in diabetic and nondiabetic women (panel A) and men (panel B).
As expected, diabetic subjects had a significantly elevated random glucose level, albumin-corrected fructosamine, and creatinine compared to controls (Table 2). Although total cholesterol did not differ between diabetic and non-diabetic subjects, HDL cholesterol was significantly lower and total triglycerides were significantly elevated.

Compared to non-diabetic controls, diabetic individuals reported significantly worse self-rated health and physical functioning, although the difference on BADLs was small and non-significant (Table 3). Diabetic subjects experienced more falls and more injurious falls than controls, but GDS and MMSE scales showed no significant difference between groups. Diabetic subjects demonstrated minimal differences in strength, balance, and timed performance compared to controls (Table 4). Diabetic men tended to have slightly worse (but statistically insignificant) performance compared to controls, but among women the trends toward better performance did not consistently favor one group over the other. Results in Tables 3 and 4 did not change in any substantive way when an increased fructosamine was included in the determination of diabetic status.

The first set of multivariable analyses based on the diagnosis of diabetes (Table 5A) demonstrated that the relationship between diabetic status and IADL dependencies, Rosow-Breslau functioning, and Pincus-3 score could not be explained by differences between the two groups in age, gender, BMI, AHR, or history of stroke. Sensory deficits (pin-prick, light touch, and vision) appeared to explain a large amount of the association between diabetic status and Pincus-3 and a substantial amount of the associations with IADL dependencies and Rosow-Breslau. Medications and medical problems provided additional explanation for IADL dependencies but not for the other two outcomes. BMI, AHR, and stroke appeared to explain some of the association between diabetic status and self-rated general health, and controlling for sensory deficits almost completely eliminated the association (Table 5B). For falls, all factors except stroke increased the odds ratios associated with diabetic status, but the 95% confidence intervals usually included one.

The number of subjects available for the fructosamine-based set of analyses was smaller than analyses based on the diagnosis of di-
### Table 5. Multivariate Analyses Evaluating the Effect of Explanatory Variables on the Association Between Diabetic Diagnosis and Glycemic Control on Outcome Variables

#### A. Continuous Function Frailty Dependent Variables

<table>
<thead>
<tr>
<th>Explanatory Model</th>
<th>IADL Dependencies</th>
<th>Rosow-Breslau</th>
<th>Pincus-3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Beta</td>
<td>p value</td>
<td>Beta</td>
</tr>
<tr>
<td>Diabetes alone</td>
<td>0.088</td>
<td>0.026</td>
<td>0.146</td>
</tr>
<tr>
<td>+ Age, Gender</td>
<td>0.107</td>
<td>0.006</td>
<td>0.161</td>
</tr>
<tr>
<td>+ BMI, AHR‡</td>
<td>0.207</td>
<td>0.007</td>
<td>0.192</td>
</tr>
<tr>
<td>+ History of stroke‡</td>
<td>0.161</td>
<td>0.044</td>
<td>0.142</td>
</tr>
<tr>
<td>+ Sensory problems§</td>
<td>0.137</td>
<td>0.086</td>
<td>0.152</td>
</tr>
</tbody>
</table>

#### B. Dichotomous Frailty Dependent Variables

<table>
<thead>
<tr>
<th>Explanatory Model</th>
<th>Fair or Poor SRH OR (95% CI)</th>
<th>Any Fall OR (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diabetes alone</td>
<td>1.71 (1.13,2.59)</td>
<td>1.68 (0.99,2.87)</td>
</tr>
<tr>
<td>+ Age, Gender</td>
<td>1.75 (1.15,2.65)</td>
<td>1.85 (1.07,3.2)</td>
</tr>
<tr>
<td>+ BMI, AHR‡</td>
<td>1.68 (0.65,4.39)</td>
<td>2.39 (0.68,8.35)</td>
</tr>
<tr>
<td>+ History of stroke‡</td>
<td>1.61 (0.61,4.23)</td>
<td>2.04 (0.56,7.41)</td>
</tr>
<tr>
<td>+ Sensory problems§</td>
<td>1.10 (0.38,3.30)</td>
<td>2.79 (0.68,11.53)</td>
</tr>
<tr>
<td>+ Medical problems§</td>
<td>1.44 (0.45,4.63)</td>
<td>3.87 (0.79,18.91)</td>
</tr>
</tbody>
</table>

#### Notes:
- Except as indicated, N = 634 to 637. All dependent variables were scaled such that an increased score indicated worse functioning. For descriptions of variables, scales, and analytic approach, see Methods. IADL = instrumental activities of daily living; BMI = body mass index; AHR = abdominal-to-hip ratio; Beta = standardized beta from the ordinary least square regression analysis.
- "Explanatory model" description explains which variables are included in the model. A "+" indicates that a variable is added to all prior variables. Statistical result represents the association of either self-reported diabetes diagnosis or fructosamine level with the dependent variable, controlling for all other factors added to the model to that point.
- "N = 156–172, depending on frequency of missing data.
- "Sensory problems" include pin-prick and light touch in feet on examination and reported visual functioning (excellent, very good, good, fair, and poor).
- "Medical problems" include number of medical diagnoses and number of daily medications.

### DISCUSSION

Several findings previously demonstrated in other diabetic populations were confirmed in our sample of older African Americans. Specifically, our diabetic subjects reported more functional disability and worse general health than did age- and gender-matched nondiabetic controls (12), and the majority of the diabetic individuals were not obese, in contrast to younger Type II diabetic individuals (5,6).

Our analyses extend prior studies in several regards. First, the excess disability that has been well described in general populations of diabetic persons, most of whom are white (12), was also demonstrated in this study's diabetic older inner-city African Americans. Second, this diabetic group demonstrated more deficits compared to controls in higher level functioning (IADL, Rosow-Breslau, and Pincus-3 scales) than lower level functioning (BADL). Third, diabetic subjects reported more falls and injurious falls than did nondiabetic subjects. This phenomenon has been reported in Finland (20), but we have been unable to find population-based studies documenting its occurrence in the United States.

Fourth, we attempted to define reasons that diabetic subjects reported worse functional health status than did nondiabetic controls. Somewhat surprisingly, we were unable to demonstrate any consistent difference between the two groups on strength, balance, or timed performance measures. All measurements were obtained either by a single investigator (DKM) or a well-trained research assistant.
assistant, using standardized protocols based on recommended measurement techniques and blinded to diabetic status. Therefore, we doubt that biased measurement caused the lack of association. In contrast, visual dysfunction, distal sensory deficits, medications, and other medical problems appeared to explain some of the association between diabetes and dysfunction. These findings are consistent to some extent with the limited data that are available. Brown and colleagues demonstrated that muscular strength does not adequately explain differences in physical functioning, and that factors other than strength appear to play a substantial role in functional performance (38). Simioneau and colleagues (15) showed that distal symmetrical sensory neuropathy had a markedly detrimental effect on postural stability in a sample of medical outpatients, and this effect was greatest when visual or vestibular cues were degraded or absent. In our study, deficits in vision and distal sensory function appeared to explain the association between diabetic status with higher level functional deficits but surprisingly not the association with reported falls. The reasons for this discrepancy are unclear.

Previous studies on falls have frequently implicated polypharmacy as a contributing factor to falls (49,50), and diabetic subjects in our study took nearly twice as many medications as non-diabetic controls. However, using our multivariable modeling technique based on the method of Eley and coworkers (47), medications and medical problems did not help explain the association between diabetic status and falls. Part of the problem may come from overtraining of the multivariable models in this exploratory part of the study.

Why glycemic control was more closely associated with higher level functioning than falls and general health was unclear from our data. It may be that the most functional diabetic individuals pursue healthier lifestyles and better diabetic management, which combine to improve glycemic control. This hypothesis was not testable with our data.

Overall, these results suggest that diabetes causes considerable excess functional disability for older inner-city African Americans, involving deficits in self-care functioning similar to those seen in primarily white populations (12) as well as falls and injurious falls. The linkage between diabetes and disability appears to operate similarly in our study group as in other populations (12,14–16), and our investigation has attempted to generate further insight into this phenomenon. Additional studies examining the cause of increased frailty in diabetic seniors and controlled interventionist studies aimed at reducing frailty (especially falls) in the elderly diabetic population need to be undertaken. This is particularly important for the African American population because of the increased prevalence of diabetes in this group. Whether the causation of frailty in diabetic persons or the response to intervention differs between African American and whites also deserves further investigation.

In the meantime, the study by Tinetti and coworkers (51), demonstrating that the correction of multiple minor problems prevents future falls, may provide some guidance for the clinical care of older diabetic patients. It is reasonable to assume that diligent care focused on correcting as many problems as possible, while minimizing the number of medications, may help mitigate the negative impact of diabetes on the older patient’s functional status.

ACKNOWLEDGMENTS

This study was funded by Grant 5 RO1 AG10436 from the National Institute on Aging’s Minority Physical Frailty program and presented in part at the 49th Annual Scientific Meeting of The Gerontological Society of America, Washington, DC, November 19, 1996. Ms. Lui is currently with the University of California San Francisco School of Medicine.

The authors appreciate the assistance of the staff at the Community Health-in-Partnership Services in support of this study, and Dr. John Baty for statistical advice. Any errors and omissions, however, are solely the authors’ responsibility.

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Received January 22, 1998
Accepted June 28, 1998